INFINITE ENERGY™

The Magazine of New Energy Technology

New Energy • New Science • New Technology

Volume 9 • Issue 50 • 2003

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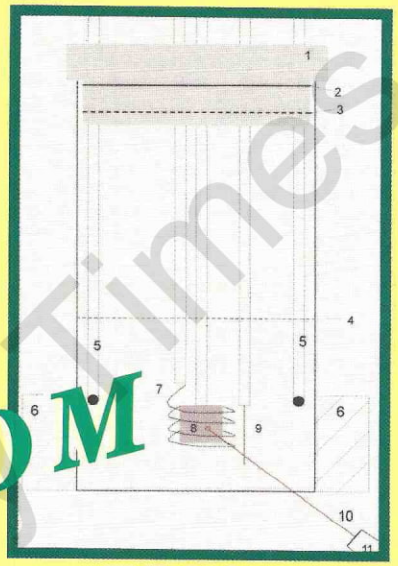

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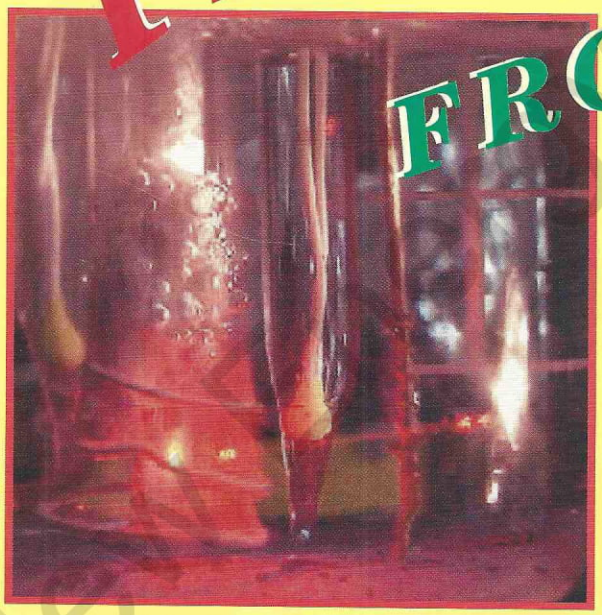

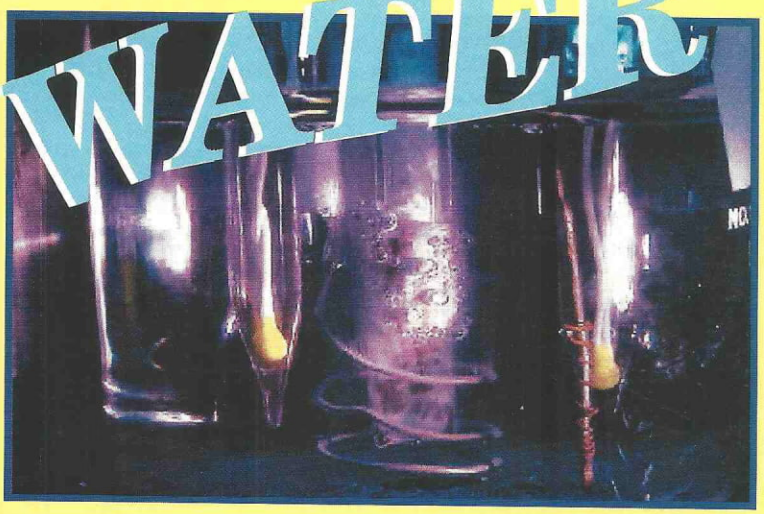

A New Light on the "Cold Fusion" Enigma

50

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ICCF10

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August 24 - 29, 2003

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- *Temperature increases, power and energy production in metal hydrides/deuterides; calorimetry relevant to such experiments*
- *Charged-particle, X-ray, and gamma emission from metal hydrides/deuterides*
- *Electrochemical issues concerning loading, surface chemistry, resistance diagnostics, and other issues concerning metal hydrides/deuterides that relate to anomalies*
- *Production of new elements or isotopes in metal hydrides/deuterides*
- *Tritium production in metal hydrides/deuterides and induced radioactivity*
- *Materials science issues that are important for the development of nuclear effects in condensed matter*
- *Models for relevant nuclear processes in the condensed matter environment*
- *Correlations, or lack of correlations, between energy production and possible nuclear products*
- *Demonstrations*

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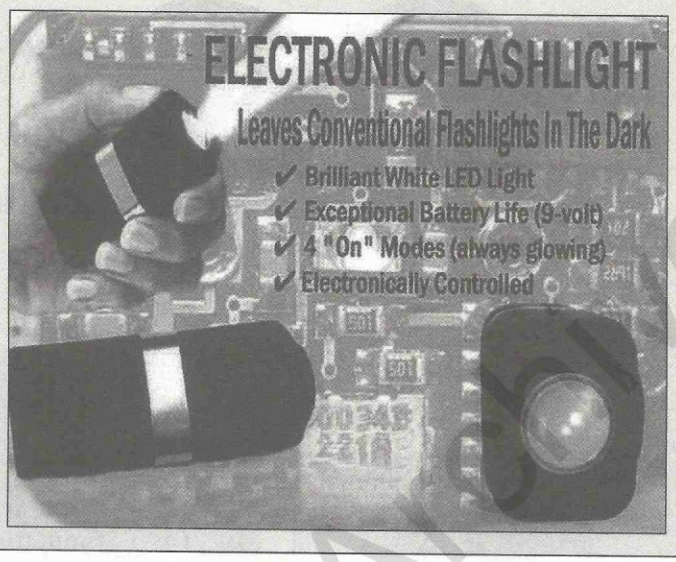

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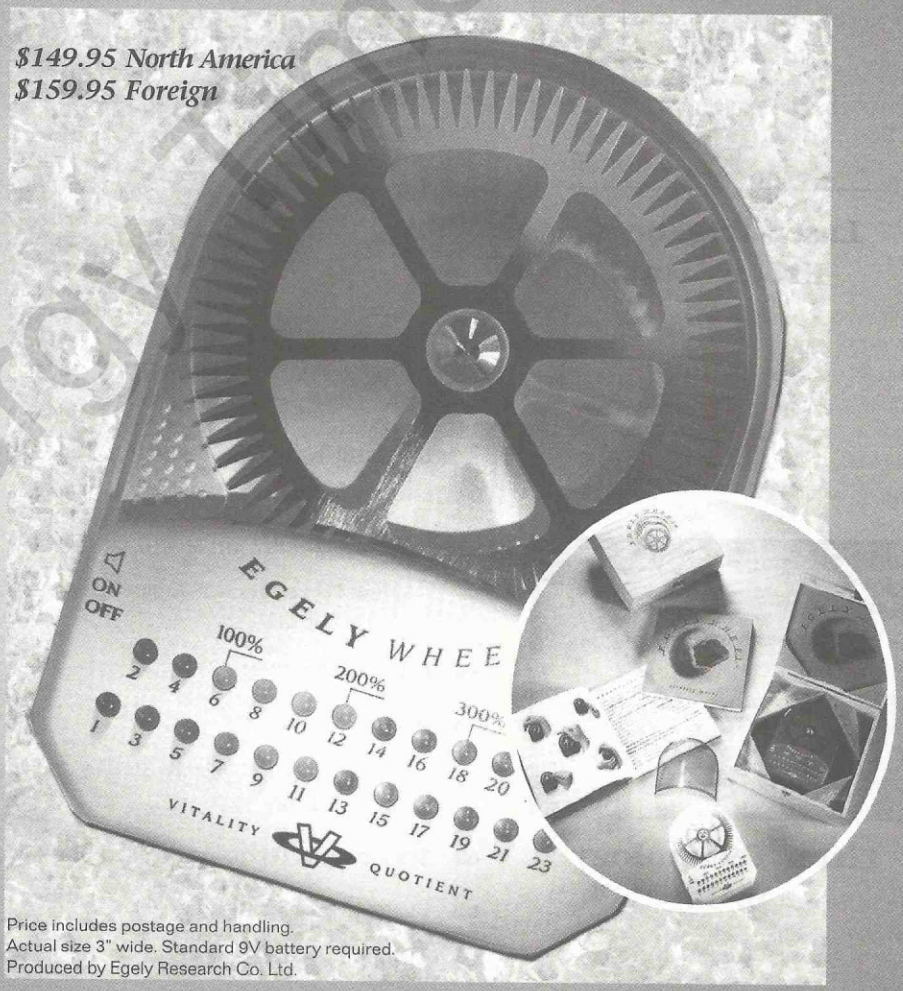
—G. Egely



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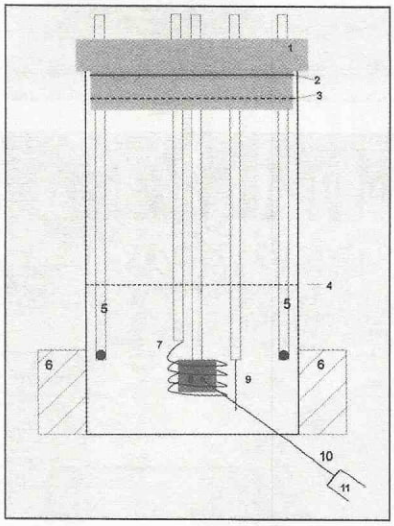

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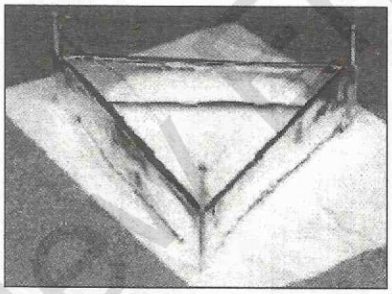

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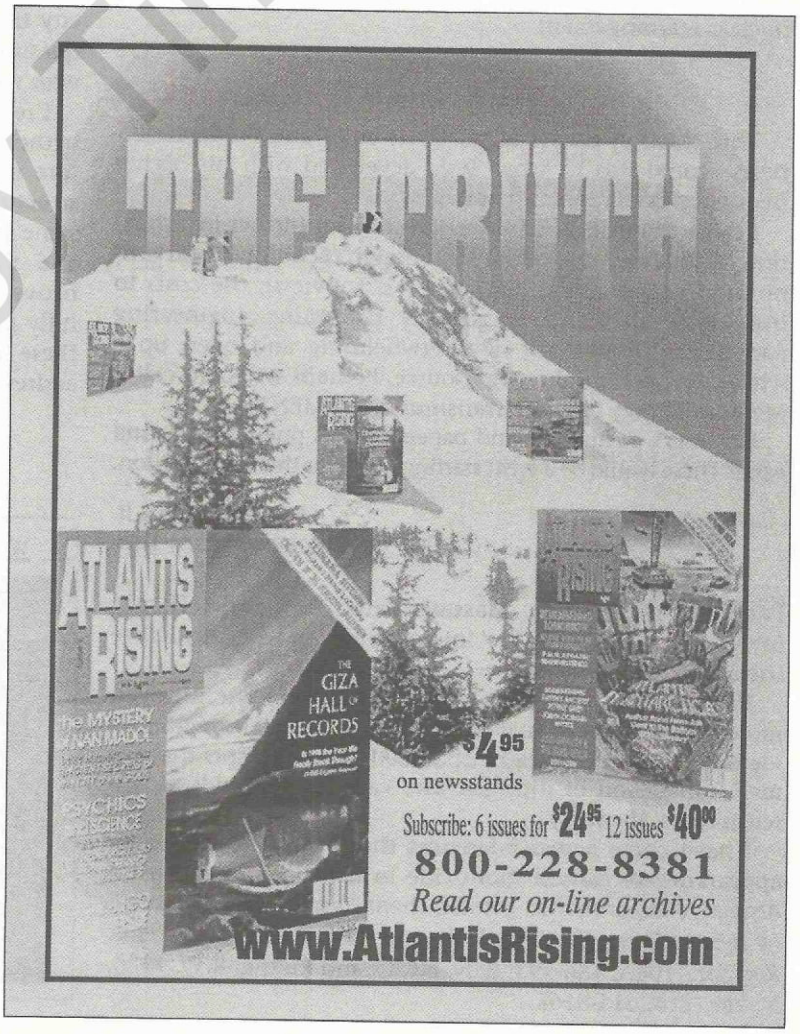


LETTERS TO THE EDITOR

Connections?

Your Tesla issue (#48) brought together two diverse pieces of information that might be significant to the *Infinite Energy* community.

Item 1: From his "The Problem of Increasing Human Energy," Tesla describes the burning of atmospheric nitrogen: "from an insignificant brush-discharge a few inches long it developed into a marvelous electrical phenomenon, a roaring blaze, devouring the nitrogen of the atmosphere and measuring sixty or seventy feet across." This was accomplished using high voltages and a frequency of about 100 kHz.

Item 2: This item is from a recent article whose source escapes me, as it was embedded in a larger article not directly involved with this subject and I haven't been able to locate it.

Back in the mid-1940s, welders using nitrogen as the inert gas in their process were coming down with a mysterious illness. This illness was found to be carbon monoxide poisoning. The investigators were able to rule out contaminated nitrogen. They then conducted experiments that rigorously excluded any carbon from the process and still found carbon monoxide being generated. The problem was solved by discontinuing the use of nitrogen and going to other inert gases.

The tentative hypothesis to explain this observation was a nuclear rearrangement:

$$\underset{\text{m.wt 28}}{N_2} \rightarrow \underset{\text{m.wt 28}}{CO}$$

This reaction occurs at relatively mild and crude conditions—could this be what Tesla developed with his higher frequency excitation and voltages?

I think that this phenomenon is due for further investigation. With current experimental design techniques and economical experimental hardware (*i.e.* Labview), the costs to investigate this and empirically determine engineering parameters should not be overwhelming and open up a whole new potential energy source. Perhaps we could call it Medium Energy Nuclear Transmutation (MENT).

Do Tesla's documents and papers on this phenomenon still exist? These would be a great starting point for this investigation.

James Wenskus, Jr.
Rochester, New York

Paul Rowe (Mashpee, Massachusetts) Responds: Thanks for sharing James Wenskus' interesting letter with me. I have the following comments:

Nitrogen has an atomic weight of 14.008. The nitrogen molecule has a molecular weight of 28.016. Carbon monoxide has a molecular weight of 28.000. If one accepts that $E = mc^2$, conversion of nitrogen into carbon monoxide would release lots of energy.

I have come across references that claim the surprising appearance of carbon monoxide in low pressure electrical discharge experiments. I noted them in my paper in Issue 8 of *Infinite Energy* [Riding, R.W. and Baly, E.C.C. 1925. *Proc. Roy. Soc.*, 104A, 186-193; Baly, E.C.C. and Riding, R.W. 1926. *Nature*, 118, 615-616].

Tall Building Design for Cities

I just read Bill Zebuhr's cover article of Issue 49, "Defiance Rising: Super-Tall and Ultra-Secure Buildings." I "took a shot" at this World Trade Center issue a year and a half ago. I sent a letter/proposal to New York City Mayor Rudolph Giuliani in late December 2001. The best that one could expect is a thank-you letter—and I received one from Mayor Giuliani's office.

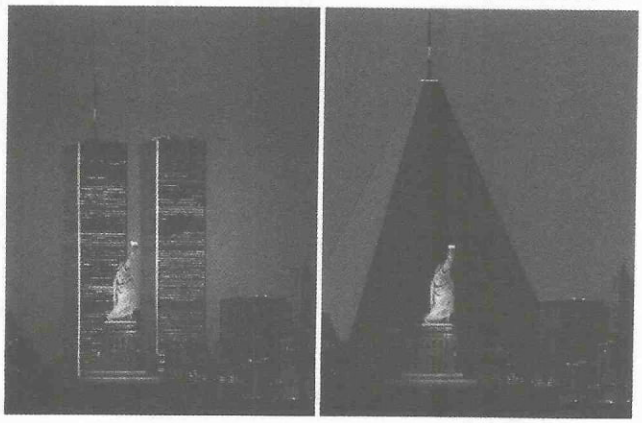
My World Trade Center Pyramid Project Proposal is an idea that I thought of for replacing the Twin Towers, which were destroyed September 11, 2001. The pyramid would be fabricated from reinforced concrete in lieu of structural steel. The base of the pyramid structure would be 1,000 feet square (1,000,000 square feet in area). The height from the base to the observation deck/roof would be approximately 1,680 feet, which would make it the tallest building in the world. A 360-foot tall television/communications mast would be erected on the roof, as it was with the previous North Tower. The roof would be 100 feet square (10,000 square feet in area).

As Mr. Zebuhr has, one starts to think about starting a new city from scratch out in the middle of nowhere. Then, the question is: "Where is the money going to come from, and who will take interest in such a project?"

I resided in New York City for about two years and left it without regret twenty-five years ago. The social infrastructure needs to be addressed as well as the technical infrastructure. The large cities in this country typically have the same problem. They are inhabited by the extremely wealthy and the extremely poor, as well as the "struggling in-between." Just as the search for "infinite energy" will hopefully give all of us hope for a fair chance in life, so should these futuristic city ideas, in my opinion. Mr. Zebuhr briefly addresses this issue in his article.

Bill Simpson
Groton, Connecticut

WORLD TRADE CENTER PYRAMID PROJECT PROPOSAL



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Metaphorically Speaking. . .

Thank you for printing Kevin Varner's deathless prose ("Perpetual Motion in the 21st Century," *IE* #43). We need more writers/thinkers like him, carefully documenting his rushing in where High Priests fear to tread. . .this rushing in may be easier to do if your mind hasn't been damaged by being a graduate student and then a faculty type. If any faculty types survive the mind-numbing process intact it is in spite of the system, not because of it. We all suffer when religiosity infects science, when the High Priests set something like the Second Law of Thermodynamics up on the altar, and only physicists can be High Priests, and the chemists and nuclear engineers don't even get to be altar boys. So it is good when free spirits like Varner weigh in and give us a refreshed and even copiously illustrated version of things, without altars and genuflection.

I admit his article caused me to realize how little I knew about osmosis, and I appreciate his attempt to educate us all about the potential of the New Osmosis for some kind of anti-second law, over-unity, "perpetual motion" device.

However, there are questions remaining in my mind about what exactly the New Osmosis is. And my questions seem to revolve around some metaphors that Varner introduces without ever telling us what they really refer to.

For instance, Varner uses the word "tether" in a way that is not, ultimately, transparent. It occurs first on page 28: "I propose that all an experimenter has to do is to *tether a monolayer* of impermeable solute molecules *onto one side* of a semipermeable membrane. . ." In Figure 6, which goes with the just quoted passage, there is actually what I take to be a depiction of particles "tethered" to the semi-permeable membrane, on one side of the anti-second law "perpetual motion" machine, though it is not at all clear how these particles are themselves "impermeable." And it is not clear how serious Mr. Varner is about this Figure. There is no further explanation of the device in the picture, or in any of the subsequent pictures or text. There is no explanation of the "paddlewheel" (is this another metaphor, unexplained?), or what appears to be a descending series of pools of the solvent, or whether gravity is a factor. If it is, what is holding the solvent in the device? What is the "tether" made of, or if it is just energy, how does it maintain its "tethering" function? Is the "tethered solute" so powerful it dominates the whole machine, including the solvent itself?

The primary meaning of tether, as a noun, is a rope or leather strap used to tie a horse or a donkey to a hitching post, and by extension any animal, and by further extension any loose tie. A rigid connection would be a "bar" or "rod" rather than a "tether." Is there some reason to use the word "tether" in this development of the New Osmosis, rather than a word like "tie" or "attach" or "bond"? Do we need to think of whatever the tethered solute is as lively, like a horse or a donkey, free to move a little, within the restriction of the tether, but otherwise tied to the semipermeable membrane?

These are questions that flow naturally from the metaphor itself, and it seems to me Varner is obligated, in some way, to explain what the word "tether" is doing there, why is it important for understanding whatever is going on with a "tethered" solute, that is presumably *not* going on with an untethered solute.

A metaphor works when it carries meaning. The Greek roots of the word are instructive here. "Meta-" means over, or above, or across, "-phor" comes from "pherein," a verb meaning "to carry." So a metaphor is a word that carries meaning across from the noumenal realm, the mind of the speaker/thinker, to the physical realm we have in common, and in terms of which most language works.

The reality of Varner's world, in the new osmosis, is the reality of solvents and solutes and permeable and semi-permeable membranes, and all the possible combinations of these elements, made of whatever material, at whatever level of magnification they are named. So solvents and solutes and semi-permeable membranes are what we have in common, and what does not need to be explained. But now here comes Varner with his tethered solutes, and suddenly we have something strange, not common. And after his meander through the literature, which begins on page 29, when he starts to look at competing theories, I still don't know what he means by importing that word into the discussion.

I am deeply uncomfortable with Varner's assumption that scale does not matter, that beans and marbles will act just like molecules or nano-particles, when clearly they don't. And gravity is just one factor. I think that the smaller the scale, the more likely that electromagnetic forces dominate and the less likely that what appears to dominate at larger scales (gravity, inertia, friction, etc.) applies. Friction is another mystery, perhaps. But even so, I would like to see a more full discussion of exactly what tethering is in the new osmosis. If it is molecular (on page 29, Varner refers to "uncooled *molecular* solutes held in place with *molecular* chain/tethers. . .") then surely it matters, here and there, what molecules, exactly, you are talking about. A molecule of glucose surely acts differently in almost every context than a molecule of, say, some hydrocarbon.

Of course, Varner has had a bad example in front of him the whole time in the form of "Maxwell's Demon" and the "trapdoor" in the Gedanken experiment that became such a bugaboo for generations of people trying to think sensibly about random molecular motion of gases. Demons and trapdoors are words from the macro-world of ordinary language. They have no technical definition at all. Easy to remember, in a context of talk about Brownian motion, but not particularly illuminating in a microscopic world, and begging for some clearer explanation. Imported into the scientific context of talk about gases and random motion, they are metaphors, and only serve as catchy place-holders until something better comes along.

I know my problems with "tethered solutes" may be a function of my lack of scientific expertise. I had physics and chemistry in college, as "natural science" requirements, but nothing further. . .and my Ph.D. is in English literature. But I did learn how to read, in the course of doing a Ph.D., and the point about how metaphors work, or don't work, is perfectly general. If you introduce a metaphor, in a context where it has never appeared before, you better be ready to explain it, in terms that are already familiar in that context. It may be perfectly self-explanatory to you, but I can assure you, it won't be to many others. Varner really might mean "tether"—because those molecules in the tethered solute really might be very lively, like donkeys and horses. And the connectedness might be very loose, like one or both ends of a tether. But these are things that need to be spelled out a little. Tether that metaphor to the page and give us more of what you mean by it, Kevin. We will all be better off.

Susanna Felder
Fairfield, Iowa

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The Editor Responds: Thank you for your appreciation of Kevin Varner's article and your very good observations about the effects of the scientific priesthood. You also had some technical queries that are easy to clarify. The "impermeable" solute molecules are dangling in the solvent flow stream, tethered by a thin, "stringy" molecule that keeps them attached to the bulk part of this semi-permeable New Osmosis membrane. The solute molecules are inherently "impermeable"—no other molecule can penetrate through such a molecule. The "paddlewheel" is literally that (or its molecular equivalent): a mechanical method of taking fluid already lifted by the New Osmosis process and having it fall down a slope while pushing the fins of a paddlewheel structure of some kind—just like a mill's water wheel. This is the means of converting the potential energy of the raised solvent to perform useful work. Yes, you have put your finger on the central contention by Varner, which not everyone will accept, that scaling down or up preserves the general validity of his electromechanical process. I believe he is well-tethered on this point—you should pardon the pun and metaphor. —*EFM*

The Whole Nine Yards

Kudos to Christopher Bjerknes. His article ("A Response to *Physics World's* 'Review' of *Albert Einstein: The Incorrigible Plagiarist*," *IE* #49) is of monumental importance to the history of science. If your review of his book (*IE* #47, by Dr. Thomas Phipps, Jr. [referenced in a Letter to the Editor in *IE* #49 by Mr. Pappas]) was somewhat timid, your publishing of his article is indeed going the whole nine yards.

Dean Pappas
Tampa, Florida

A Pre-Conference Critique of ICCF10

I deplore various administrative aspects of ICCF10, and have suggestions for improved handling of ICCF11.

The conference lacks clear planning and focus. Rather than leave the program open, and at the discretion of the "organizers," a program outline should have been promulgated well in advance and publicized. I suggest, for example: experimental work on, for instance, catalytic fusion, electrochemical heat effects, transmutation, and theoretical studies on LENR.

The conference was not made readily accessible to interested parties. There were no mailings to prior attendees, the announcements were on short notice, rather non-specific, and not widely based. The submission of abstracts via the website was *a priori* limited to those well-acquainted with Microsoft software (demonstrably not a requirement for scientific endeavor).

The chosen location, the Royal Sonesta Hotel in Cambridge, Massachusetts, is not near public transportation, nor easily available from the airport, nor is it proximate to restaurants, etc. This means a lot of taxi rides and car-pooling for the attendees.

The attendance fee is outrageously high. One can guess that the costs for meals and conference rooms at the location are high, and not well-negotiated, but can be nowhere near $450. The attendees appear thus to be sponsoring a slush fund somewhere in the range of five figures. I, for one, decry forced contribution to discretionary shenanigans.

The entire tenor of the conference is thus that it caters specifically to the "true believers," and generally ignores educating skeptics and the public of the genuine progress recently (and not so recently) made in the areas of our interest. This is no doubt the worst shortcoming, and contributes strongly and deliberately to mistrust and skepticism of our objectives, and heads toward still another year in purgatory. Further, I condemn continued reliance on the term "cold fusion," which is inaccurate and pejorative. The term "catalytic fusion" is proven accurate, and the term "LENR" is fuzzy and generic enough to be used instead.

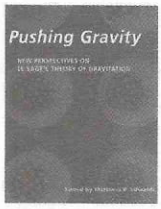
I look forward to a more propitious ICCF11.

Les Case
Newfields, New Hampshire

The Editor Responds: Dr. Case's letter was submitted to *Infinite Energy before* ICCF10. Perhaps the conference will have caused him to modify his opinions? He raises some provocative points about how well the cold fusion field organizes and publicizes its activities. Yes, these can be improved. And we are indeed in a period of transition when, as an example, not everyone will have easy facility in submitting abstracts electronically. Dr. Case is notable for his continued use of a typewriter—very retro-technology for one who has made such a remarkable advanced breakthrough with his "catalyzed fusion" process. However, we strongly disagree that the site of ICCF10 is very far from transportation nodes or that the room charges or registration fees are out of the ordinary! Some of the conference fees go toward supporting the travel of some foreign scientists, *e.g.* from Russia, who might otherwise not be able to attend the conference. And, bona fide journalists who show up get to eat for free at ICCF10's expense. Let's hope they write good stories after they sample the good science and the food!

There is certainly no "slush fund" growing out of ICCF10 (far from it!)—although we have in the past been accused by critics of siting our conferences at posh resorts from Maui (ICCF4) to Monte Carlo (ICCF5). Cambridge, Massachusetts is no such posh resort town, of course—unless one wishes to luxuriate among the magazine and book stacks in the MIT library, as Dr. Case and I have separately done in our MIT "IHTFP" days.

As for the term "cold fusion" and "LENR," I fear that we are stuck with these as the best nomenclature until a deeper understanding of the microphysics is reached. Even "catalytic fusion" has its limitations. Les, relax and enjoy ICCF10 with some good wine and good company, as I know you will. —*EFM*



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Over-Unity: The Cold Fusion Canary Sings—and Flies!

by Eugene F. Mallove, Sc.D.

It is June 2003 as this, the 50th issue of *Infinite Energy*, begins to go to press—a hard-won milestone. May there be an *IE* #100 and may most of you be with us in 2011. We are all too aware that our over eight years of publication comprise more than half the span of the "Cold Fusion War," which began March 23, 1989. The 10th International Conference on Cold Fusion approaches this August, in Cambridge, Massachusetts—not far from where some of the first shots of that interminable conflict were fired. Welcome all ICCF10 attendees from North America and most of the other continents! You are attending a most stimulating conference, we trust, and you will be receiving *Infinite Energy* No. 50 at ICCF10 *gratis*, as has been our custom beginning with Issue #1 at ICCF5 in Monte Carlo, Monaco in 1995.

Our cover heralds a new direction in the struggle to understand cold fusion phenomena. Dennis Letts and Dennis Cravens of Texas and New Mexico (the nuclear-named duo, "D + D") are pioneering a method of triggering or enhancing the traditional Fleischmann-Pons excess heat reaction in a palladium/heavy water cell by focussing laser light on its palladium cathode. The incident 30 milliwatts of red laser light is amplified many-fold and an excess heat appears from within the cell. This experiment really does *look like* "Fire from Water," but the proof is in the carefully gathered data of many experiments. What physical understandings will emerge from this enticing methodology, which appears to be a highly reproducible process? Perhaps we shall hear ICCF10 Conference Chairman MIT Professor Peter Hagelstein's proposal about what may be going on with the lattice vibrations in the palladium-deuteron complex as the coherent light strikes its surface.

As we go to press, we have learned that others have reproduced the laser-triggered excess heat phenomenon. One example: At my recent visit to the laboratory of Dr. Mitchell Swartz in Wellesley, Massachusetts, I was able to view one such successful experiment—developed independently of the Cravens/Letts approach and carried out in a very different manner. Thus, the generic light-stimulated process seems already portable from lab-to-lab and is cross-checked with several kinds of calorimetry. At ICCF10 we expect to hear from two other groups reporting positive results with this generic method. Perhaps the high-tech cache of "accepted laser physics" in this new coherent light application will encourage laser physicists around the world to try their hands at this.

Underground miners of old, it is said, brought chirping canaries with them on deep descents into mines. If a canary struggled to breath or if it died, it warned the miners of toxic or smothering gases. One might say similarly that the "cold fusion canary" has warned us too: There is a deep toxicity within the house of science, an aversion to the very, very unexpected and the radically new. If one ventures too deeply in science today to examine its foundations, one is in grave danger. "Don't ever question the foundations!" is the unacknowledged rule. Yet the cold fusion canary did not die on our descent into *terra incognita* of new physics and new chemistry in "cold fusion," though it did for a time become deathly ill. In fact, our well-born cold fusion canary showed unusual strength. It not only continued to sing and warn us as its wings flapped furiously to escape the toxic environment, but it flew high above the dark entrance to the cold fusion "mine." It saw new lands bearing other mines, some already dug deeply by others outside the cold fusion community into the heart of Nature.

Many of us entered the world of investigating "over-unity" phenomena with the Fleischmann-Pons announcement. For all its difficulties, the multiply-cross checked excess heat phenomena and the associated nuclear evidence impressed us and we are still with it. Yes, a *new energy* was there—an energy that had no right to exist, or so the textbooks said. We learned to call the excess heat condition *over-unity*, when *no conventional explanation* would explain the phenomenon. Yes, we heard the canary sing and then we saw it fly. Indeed, there appear to be many other over-unity processes, both in the laboratory and in Nature—new forms of energy that are not accepted and remain unexplained within the limited realm of textbook knowledge. When these processes are eventually explained and fully accepted, the label "over-unity" will disappear.

For those who fight the term "over-unity," an illustration may be in order: In describing the mystery of cold fusion to the uninitiated, I occasionally remark about Benjamin Franklin of the late 1700s—that if he were miraculously transported to our time and were to behold a fission nuclear power plant in operation, he would be astonished to find no evidence of wood or coal or combustion of any kind powering the plant's "steam engine." Ben would have known about steam engines, for in his day they were new and were used initially to pump water from deep mines. He would have grasped the mechanism of the steam turbine fairly easily, and he could certainly imagine that a device attached to the turbine could generate electricity ("electric fluid"), though Faraday's discoveries and Tesla's robust alternating current generators were still many decades ahead of Franklin's time.

Told about the self-heated metal within the fission reactor core, Franklin would have every right to term this an "over-

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unity" process, by our definition above. In Franklin's time, however, the law of energy conservation was still to be codified; it was only dimly perceived. So, Franklin may legitimately have wondered whether some kind of animating spirit or "aether" might be entering the hot uranium metal from the environment. Fission nuclear reactions would have been incomprehensible to Franklin, even if presented to his agile mind. Recall that his was the era in which *heat* was considered to be a perhaps inexhaustible aetheric fluid, "caloric."

In the 1820s, William Thompson in England (the future Lord Kelvin) would perform the first calculation that bracketed the Earth's age, if our planet were imagined to be a body that had cooled down from a state resembling the Sun's present incandescence. The relatively short lifetime of Earth, thus determined, did not seem to be compatible even with the very long estimated time needed to explain geologic strata. Later in the nineteenth century, following Darwin and Wallace, there was need for an even older Earth to "explain" evolution by random natural selection. Moreover, the very process by which the much more massive Sun generated its light and heat over extremely long periods remained unknown. So, at least for the natural process that made the Sun shine, it could then truly be termed a natural "over-unity" process. It remained so well into the twentieth century, when astrophysicists began to think that they had explained all of the Sun's life-processes with particular fusion reactions. Then came further evidence in the alleged "neutrino" deficit in the Sun's nuclear-originated emanations, showing again that physical theory was not as tidy as had been thought. . .The Sun was "over-unity" well into the twentieth century, and because of unresolved questions about the temperature of its upper atmosphere (its corona) and many other dangling issues, it remains part of an over-unity puzzle.

The "cold" rocky planets of the Solar System—even Earth itself—are enduring over-unity mysteries. Radioactivity within the smaller planetary bodies is said to be the most likely source of a rocky planet's internal heat, but this is by no means certain. There are theories of "pushing gravity" that rely on cosmic fluxes of graviton particles that may more elegantly (than General Relativity) explain not only gravity but the internal heat of all the planets as well. Such gravitons may collide inelastically and "stick" to other matter within a planet and thus heat it. The gas giant outer Solar System planets, in particular, are significantly over-unity in their energy budgets—emitting vastly more power into space than they receive from the light of the Sun.

It is my studied conclusion that over-unity is a much more widespread condition within Nature than has heretofore been recognized. This widespread over-unity has been papered over by the self-satisfied certainties of the physics establishment—the very group that was most responsible for trashing the work of Fleischmann and Pons and its legacy. There are the over-unity water arc and air arc electric discharges of Drs. Peter and Neal Graneau. There is significant evidence of over-unity in certain plasma arc discharges within water, put forth by a host of experimenters around the world—not only with metal electrodes, but from carbon electrodes as well that seem to give rise to unusually energetic gases. There are cavitation/acoustic devices, such as the HydroSonic™ Pump, which generate over-unity conditions from ordinary water and metal rotating parts, seemingly with ease. It is difficult to imagine that such robust devices are part of the nuclear-type reactions considered by many of the cold fusion theorists. Then there is the "hydrino"—shrunken hydrogen—heresy of Dr. Randell Mills and his successful band of Ph.D. experimenters at BlackLight Power Corporation and elsewhere. They are now jostling gas mixtures with microwave input power and getting out copious excess heat. In some experiments, all that exists in the reaction chamber is a mixture of hydrogen and helium gas. As predicted by Mills, it apparently doesn't work when krypton is substituted for helium—very curious.

More stark embodiments of over-unity conditions are to be found in the Pulsed Abnormal Glow Discharge (PAGD™) experiments and patented vacuum discharge tubes of the Correas in Canada. Not only the Correas, but Dr. Harold Aspden of the U.K., believes that such autogenous pulsations in gas discharge tubes—which are quite visually distinct from any normal discharges—are obtaining their highly over-unity energy extraction from an aether plenum that does not require the conversion of mass to energy. The energy exists in massfree form in an omnipresent aether that was inappropriately pushed aside by twentieth century physics. This is not the supposed electromagnetic "zero-point energy," but something else entirely. A new foundation of physics will have to be prepared for the one that is quite clearly crumbling.

Finally, what may be the most important collection of over-unity processes is likely to be *life* itself. Oh, I can hear the laughter already from the *Ring-of-Truth* Philip Morrisons of this world, who believe that the caloric intake of a certain number of food morsels, such as jelly donuts, will explain *completely* the energetics of human beings—or rodents or microbes for that matter. To Morrison *et al.*, life's energies are all explained by the metabolisms registered in biochemistry texts. Bear in mind that such luminaries as MIT Professor Morrison, inappropriately rejected *all* of the evidence from the cold fusion community—excess heat, helium, tritium, *everything*. So of what value are opinions from such scientists about the full range of energies that life can muster?

Know well that the tragic history of the past fourteen years was significantly set in its course by those who excused the inappropriate shifting of positive excess heat curves in calorimetry experiments at MIT that were supposedly aimed at fairly assessing the worth of the excess heat claims of Fleischmann and Pons. Such people believe that they understand the history of science. They think that everything gets ironed out rather quickly as science "self-corrects" in its inexorable quest for the *Ring-of-Truth*. Sad to say, that is *not* how science works. The so far fourteen year-old Cold Fusion War is the merest blip in *much larger* issues that have been shoved under the rug, but cold fusion may be just the right canary that delivers the necessary and long overdue wake-up call: "All is not well, all is not well, all is not well!"

Let us take, as but one example, the controversy that arose in the late seventeenth century between Luigi Galvani and Alessandro Volta and their followers. This battle was fought—and, strangely, *continues* to be fought!—over the existence of "animal electricity." That is what Galvani termed it after excised ("dead") frog's legs were observed to twitch upon being touched by Galvani's hand-held scalpel—for some reason precisely at those moments when an electrostatic machine nearby (but *not in direct contact* with Galvani) discharged into some "electric fluid"-accumulating bottles (so-called Leyden jars). There seemed to Galvani to be a transmission through the air of some essence that was re-animating the frog legs. The preponderance of the evidence was in Galvani's favor. But Volta contested Galvani's "animal electricity" paradigm, and put forth his dissimilar

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metal "battery" paradigm as the explanation of why the frogs legs (which were hung by brass hooks on an iron frame) responded. Indeed, we can thank Volta for giving us the electrochemical battery—which in its early days ironically was thought to be a possible perpetual source of energy, a massively over-unity device! But a terrible price was paid by Volta's apparent victory over Galvani in the "animal electricity" controversy. It is a complex story, retold and recast in many accounts since then.[1,2] There is even a recent sequel in the matter: irrefutable proof that acupuncture has provable, observable physiological functionality.[3] All anatomy texts, and biology texts, are instantly made grotesquely incomplete. But when this exemplary work was presented to *Science* and then *Nature*, it was rejected *without review*. Even five life-sciences Nobel laureates petitioning *Nature* for its publication had no effect. It is not easy to determine the truth of the events of the original Galvani-Volta dispute from which this modern acupuncture sequel emerges: It is almost as though the cold fusion controversy were eventually to become widely forgotten for two centuries (as it already has been among the general populace), and is then re-discovered in the twenty-third century!

The bottom line is this: Even though it cannot be doubted that Volta's battery paradigm, as translated by electrophysiologists to explain electrical discharge (depolarization) in ion-pumping neurons, plays a significant role, it appears *not* to explain everything about apparent signaling within organisms. Horror of horrors to the theory-of-everything know-it-alls, there is another form of electricity, not massbound, but massfree, and that is precisely how the mystery of such devices as discharging electrical machines, Tesla coils, etc. can have their effect on tissues (and on inorganic systems) at a distance—and at speeds within the human body that are *at least* 1,000 times faster than nerve conduction speeds. It is the likely basis by which such "impossible" signaling through the human body via acupuncture and acupressure stimulation occurs.[3] We have a lot more to learn about life and its energies, that's for sure. Are we, in part, "over-unity" beings swimming within a sea of energetic—but not electromagnetic and "zero point energy"—aether? Very, very likely. Could there be a connection between what happens at cathode surfaces in liquid solution and from the electrical eruptions *in vacuo* in other over-unity devices? Are many of the validated over-unity processes trying to send us a message like that from the cold fusion canary? For sure. Perhaps this perspective will *spark*—you should pardon the expression—the opening of a larger perspective by some at ICCF10 and in many "cold fusion" conferences to come.

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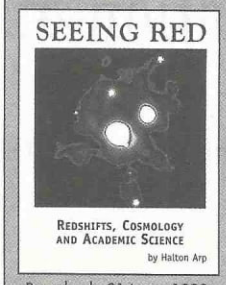

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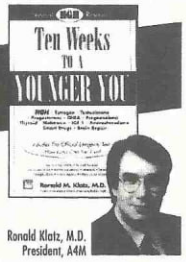

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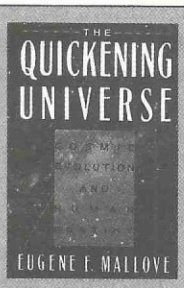

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Laser Stimulation of Deuterated Palladium

Dennis Letts* and Dennis Cravens**

Editor's Introduction

Infinite Energy is pleased to be able to publish this pioneering paper by Dennis Cravens and Dennis Letts. It presents a method for generating what the authors claim is *highly reproducible* and appreciable excess heat from deuterated palladium electrodes in heavy water cells, which are initially in calorimetric balance, *i.e.* producing no excess power. This reproducibility on demand feature—which can even be toggled off and on again—makes this laser-stimulated palladium cathode technique extremely important. Furthermore, because the excess heat is triggered by coherent light—so far in a very specific laser frequency range—the technique promises to shed much light on the basic mechanisms that allow the nuclear-scale excess-heat phenomenon to occur in "cold fusion." Perhaps the novelty of the excess heat being triggered by readily available laser sources will encourage scientists working in optics and lasers to explore this heretical field.

As we went to press before ICCF10 in Cambridge, Massachusetts in late August, it was known that a few cold fusion groups had independently reproduced some of the Letts-Cravens results. Let us hope that what these results collectively may portend for cold fusion will be discussed extensively at the meeting. —*Eugene Mallove*

Abstract

A method is disclosed to fabricate a palladium cathode that can be electrolyzed in heavy water and stimulated with a laser at a predetermined wavelength to produce apparent excess power; the fabrication method involves cold working, polishing, etching, and annealing the palladium prior to electrolytic loading with deuterium. Loading is accomplished with the cathode sitting in a magnetic field. After loading the cathode with deuterium, gold is co-deposited electrolytically on the cathode. When a coating of gold is visible on the cathode, co-deposition is halted and the cathode is stimulated with a low-power laser with a maximum power of 30 milliwatts. The thermal response of the cathode is typically 500 mW with maximum output observed of approximately 1 watt. The effect is repeatable when protocols are followed and has been demonstrated in several laboratories.

Introduction

We have been investigating the possibility of triggering a deuterated palladium cathode for more than a decade. Previously we developed stimulation methods that involved chemical, magnetic, and radiofrequency triggers. These methods worked with varying degrees of success but none was highly repeatable and robust. Until now, we had not concentrated on the metallurgical/surface aspects of the triggering mechanisms. It appears that laser stimulation of deuterated palladium is very effective when metallurgical/surface conditions are taken into account.

Experimental

Figure 1 is a typical cell configuration for our laser stimulation experiments. The cell consists of a machined Teflon lid (1). sealed with a Buna o-ring (2); gases are recombined by platinum catalyst pellets imbedded in a groove cut in the lid (3). Cell temperature is reported by the average of two Beta-Therm 10k ohm thermistors sealed inside a 5 mm glass tube (5). Electrolyte is typically 75 g of 1M LIOD (4). Two permanent magnets (6). sit adjacent to the cell. The magnets have field strength of 350 Gauss at the cathode. We think

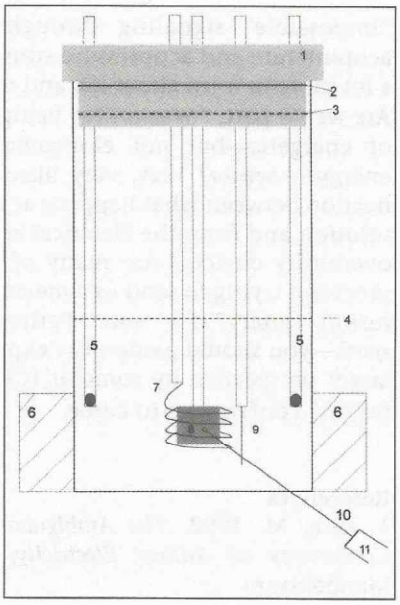

Figure 1. Typical cell configuration for the laser stimulation experiments.

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the magnetic field improves the loading of deuterium. The anode (7) is typically platinum with a coil diameter of 10 mm. The cathode (8) is typically palladium prepared according to a seventeen step protocol discussed later. The cathode is normally 5 x 8 x .25 mm.

After deuterium has been bulk-loaded into the cathode for at least 120 hours at .1 amps, current is increased to at least 1 amp for at least 24 hours. A secondary anode of gold (9) is then hooked up to the positive side of the power supply providing DC power for electrolysis. When the secondary anode is energized with positive DC current, gold ions are released into the electrolyte and eventually migrate to the cathode and are co-deposited with deuterium. When the cathode begins to turn dark, the secondary anode can be disconnected. Gold continues to plate onto the cathode out of solution. At this time a tunable laser (11) is directed onto the cathode with a spot diameter of about 2 mm.

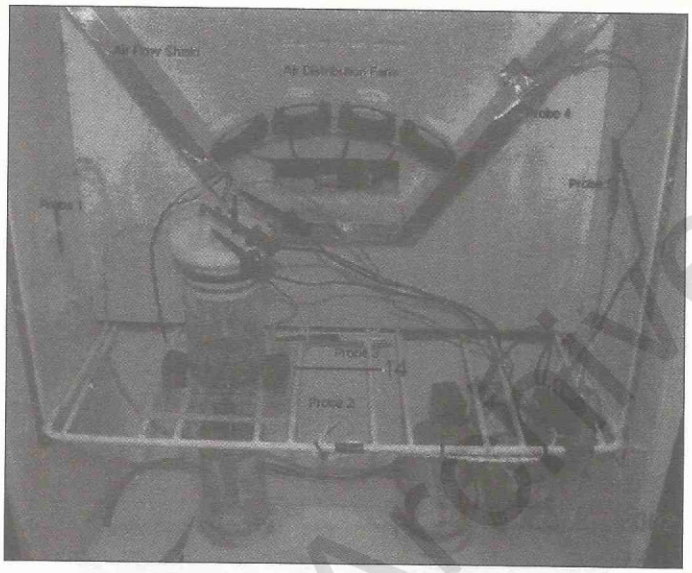

Figure 2. Cell in a temperature-controlled enclosure.

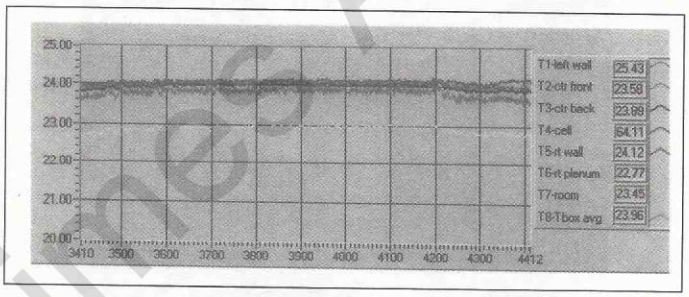

Figure 2a. Enclosure temperature of the cell.

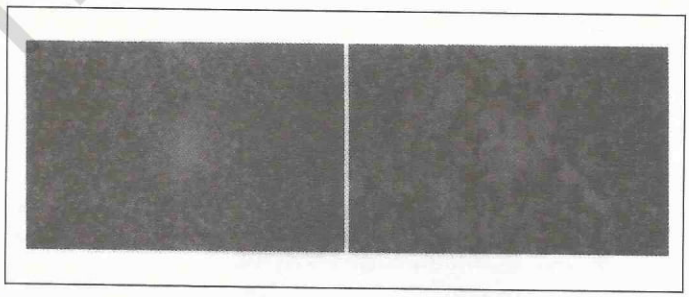

Figure 3. Two palladium cathodes prepared by cold rolling, polishing, and annealing.

Equipment

Figure two shows the cell in a temperature-controlled enclosure capable of holding ambient temperature at 24+/- .05˚C. The enclosure was modified for stable temperature control by Scott Little of Austin, Texas.

Cool air and warm air are mixed behind the blue panel and brought forward into the enclosure by the four fans shown; average enclosure temperature is computed by averaging five thermistors placed in the enclosure. The air is well stirred by the fans and is distributed evenly by a thin plastic shield placed in front of the four distribution fans. Enclosure temperature is maintained by an Omega temperature controller. The resultant enclosure temperature stability is shown in Figure 2a. The graphic shows a 15 hour run with the enclosure temperature set at 24˚C; the enclosure door was opened at point 4,200, creating a very small disturbance on the average enclosure temperature. Over 15 hours ambient enclosure temperature varied less than a tenth of a degree.

Additionally, electrolytic power to the cell is held constant so that any significant cell temperature variation of 1-3˚ must come from the cell and not its environment. The cell is not stirred but electrolyte temperature is measured in two places around the cathode. An average of the two thermistors is used.

Cathode Fabrication

The general idea behind the cathode fabrication process is to create a uniform surface while increasing the palladium grain size. Creating dislocations and defects with cold rolling is also important. The stresses induced by cold working are partially relieved by annealing as grain size increases. A seventeen step protocol has been empirically developed that produces a palladium cathode that can be triggered by a laser to evolve heat much greater in magnitude than that expected from laser heating alone. The protocol is as follows:

1. Cut a billet of palladium 10 mm x 10 mm x .5 mm.
2. Polish to bright using a dremel tool/ fiber brush and Nicksand (Al. Oxide).
3. Rinse in tap water.
4. Heat in furnace to 750˚C for 3 hours; slowly cool to ambient.
5. Etch for 2 minutes in Aqua Regia at room temperature.
6. Re-polish with dremel and a METAL brush using Nicksand.
7. Polish with dremel and fiber brush using Nicksand.
8. Ultrasonically clean for 5 minutes.
9. Anneal 2.5 hours at 850˚C.
10. Polish with dremel/metal brush.
11. Ultrasonically clean 5 minutes using an oxide remover.
12. Cold roll to .25 mm thickness.
13. Re-polish with dremel/metal brush.
14. Ultrasonically clean 5 minutes with oxide remover.
15. Anneal for 2.5 hours at 850˚C.
16. Etch with Aqua Regia for 2 minutes at room temperature.
17. Rinse in distilled water; cathode is ready to load at low current.

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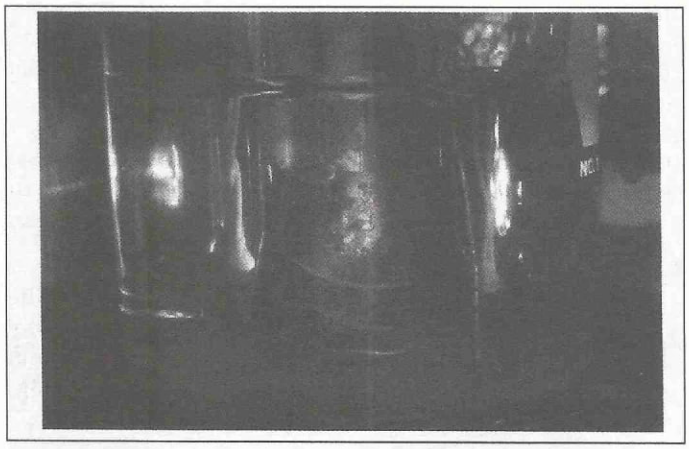

Figure 4. A cathode plated with gold.

Figure 5. Cathode being stimulated by a 682.3 nm laser.

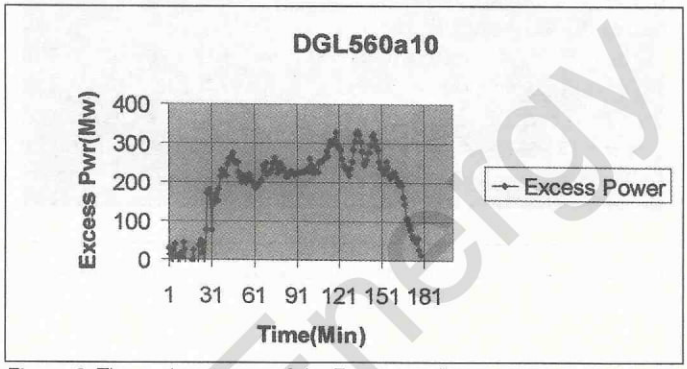

Figure 6. Thermal response of the Figure 5 cell.

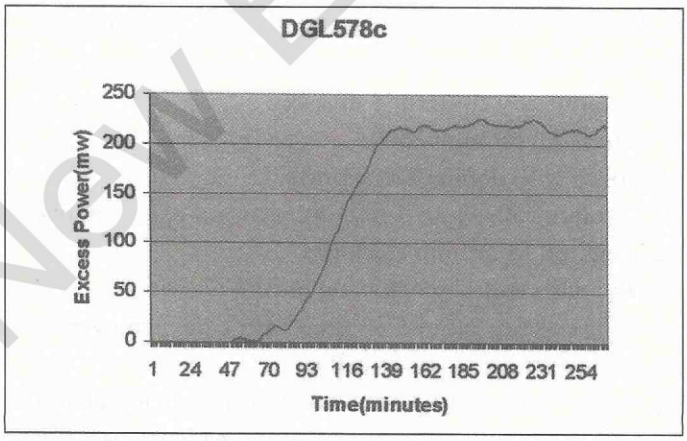

Figure 7. Thermal response of Figure 5 cell after plating gold to the cathode, 4 hours.

Shown in Figure 3 are photographs of two palladium cathodes prepared by cold rolling, polishing, and annealing; the cathode on the left was annealed once at 850°C while the cathode on the right was annealed three times at 850°C. The grains have increased in size.

Over 1,000 experiments conducted since Fall 2000 suggest that the seventeen step protocol shown above will produce a cathode that can be triggered by a laser to produce apparent excess power.

Results

It has been observed that a common red laser (30 mW) when tuned to specific wavelengths appears to trigger a cathodic exothermic reaction 5-30 times greater than the magnitude of its radiant power output. This effect has been observed many times in more than 1,000 experiments conducted between September 2000 and March 2003. The stability of ambient temperature has ranged from that of benchtop experiments to that of an enclosure with a stability of +/- .05°C. The effect has not disappeared or diminished as calorimetric quality improved. It has also been observed that the magnitude of the thermal response of the cell may be altered by the polarization of the laser beam with respect to an external magnetic field.

Figure 4 shows a cathode being plated with gold from a gold wire wrapped around the secondary platinum anode in the right foreground. Note the discoloration on the cathode, indicating that the cathode is ready for laser stimulation.

Figure 5 shows the cathode being stimulated by a 682.3 nm laser with 30 mW of radiant power. The thermal response of this cell is shown in Figure 6.

The 30 mW laser was switched on at point 30 and the cell reached a maximum excess power of 350 mW; at point 134 the laser was switched off and the excess power signal declined to baseline. This suggests to us that the excess power signal was real and not a measurement error. The irradiated area was about .03 square centimeters, making the surface power density 10 watts per square centimeter. The best solid-oxide fuel cells available today have a surface power density of 1 watt per square centimeter.

Experimentation continued into 2002; as long as the fabrication protocol was followed, the laser effect was reproducible. On October 11 and 12, 2002 the results shown in Figures 7 and 8 were obtained.

A 661.5 nm laser with radiant power of 30 mW was used in both Figure 7 and Figure 8; the principal difference between the two runs was the amount of gold plated onto the cathode. The cathode of Figure 8 received 24 hours of additional gold co-deposition.

The thermal response of the cathode was three times greater in Figure 8. At point 300 the laser was switched off and the excess power signal declined toward but did not reach baseline.

Polarization

During the course of experimentation it was discovered that polarization of the laser beam can dramatically affect the thermal response of the cathode to the laser beam. Cravens observed during one of our runs that when the laser beam polarization is perpendicular to an external magnetic field,

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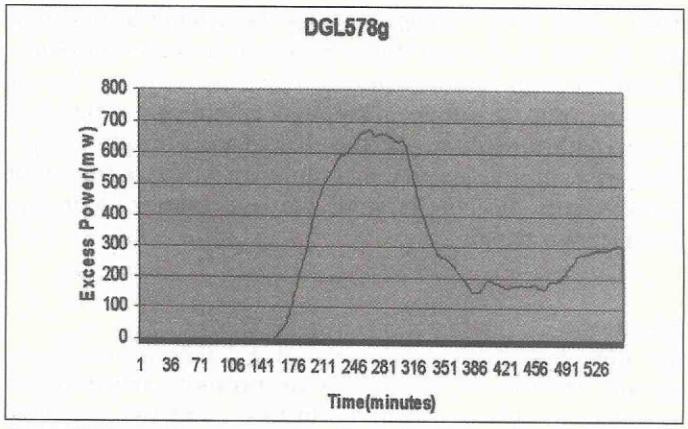

Figure 8. Thermal response of the Figure 5 cell after plating gold to the cathode, 28 hours.

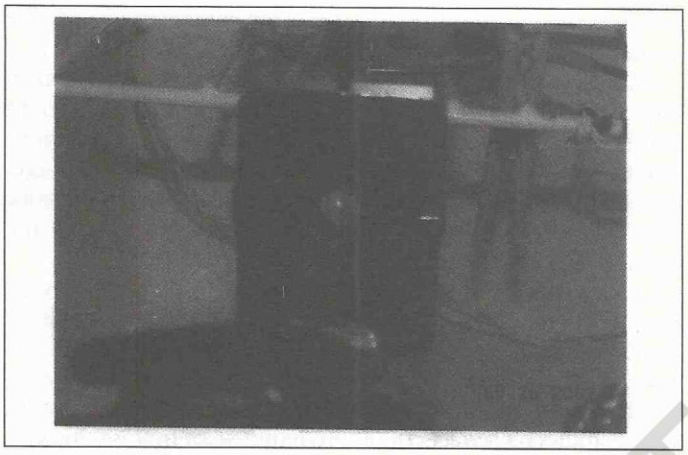

Figure 9. A 1/2 wave retarder.

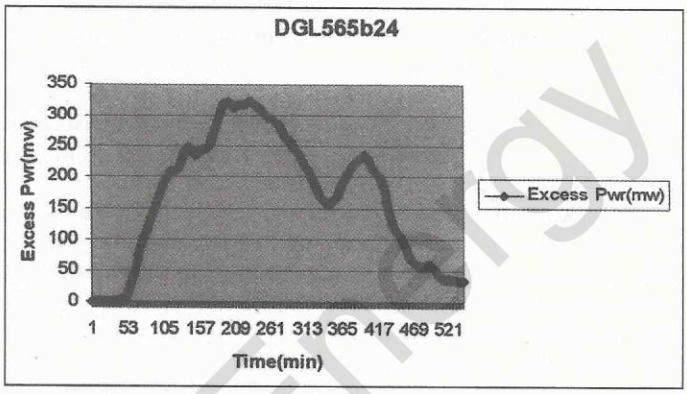

Figure 10. Results of Figure 9 cell.

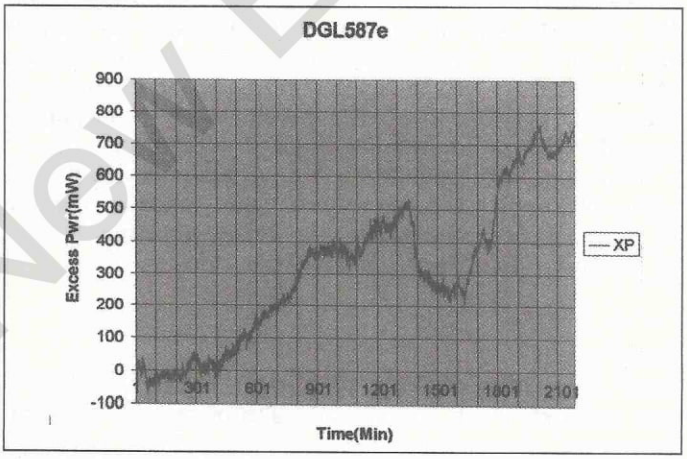

Figure 11. The Earthtech International run.

the thermal response of the cathode is maximized. The polarization of the beam was rotated with a 1/2 wave retarder; as the polarization of the beam became parallel to the external magnetic field lines, apparent excess power declined.

With the 1/2 wave retarder shown in Figure 9, the laser beam polarization was rotated with respect to an external magnetic field of 350 Gauss. The results are shown in Figure 10.

- At point 200, 1/2 wave retarder was inserted in the laser beam; excess power signal weakened immediately. The 1/2 wave retarder attenuated the 30 mW laser beam by about 1 mW. Polarization was parallel to the external magnetic field after point 200 and the excess power signal declined.

- At point 335 the 1/2 wave retarder was removed and excess power signal recovered; polarization was returned perpendicular to the external magnetic field.

- At point 400, the 1/2 wave retarder was re-inserted in the laser beam. The excess power signal reversed its direction and declined to about laser heating of 30 mw; when the beam polarization was parallel to the external magnetic field, apparent excess power declined.

The most recent experiment, #587e, was run at the laboratories of Earthtech International of Austin, Texas and was witnessed by Scott Little, George Miley, Ed Storms, and Tom Claytor. The cathode was a gold substrate 5 mm x 8 mm x .75 mm with palladium plated onto the substrate with a rare earth additive provided by Cravens. The cathode didn't respond well to the laser stimulation until the rare earth solution was added to the electrolyte. At that point the cathode became responsive to a laser operating at 657 nm with a radiant output of 30 mW. Results are shown in Figure 11.

The cell ran at about zero excess power from point 0 to point 300 (5 hours); at point 320 Letts turned on the 30 mW laser. Over 15 hours the excess power rose to 500 mW. On March 6, at point 1374, Letts and Miley visited the lab and switched off the laser. At point 1629 Scott Little switched the laser back on. It is very clear that the 30 mW laser made a difference in the thermal output of the cell amounting to at least ten times its radiant power output. During the course of this experiment the ambient temperature was held constant at 24 +/- .05°C and power to the cell was constant at 7 +/- .01 watts. The laser beam polarization was perpendicular to the external magnetic field of 350 Gauss. The recovery of the cell's thermal output from 250 mW to 750 mW was witnessed by Ed Storms, Tom Claytor, George Miley, and Scott Little.

Crude Model

A crude model has been proposed by one of us (Letts) that is probably wrong; its only redeeming quality is that it does provide a method to tune the laser. The wavelengths produced by the model have worked in the laboratory. There is no physical reason why they should work, other than luck. For discussion purposes, please consider the graphic presented in Figure 12.

The model used to compute a resonant laser wavelength is that of the Particle-in-a-Box, found in all basic quantum mechanics textbooks. The model assumes that deuterium can be localized in the open space between palladium surface atoms, thus forming a two or three dimensional quantum

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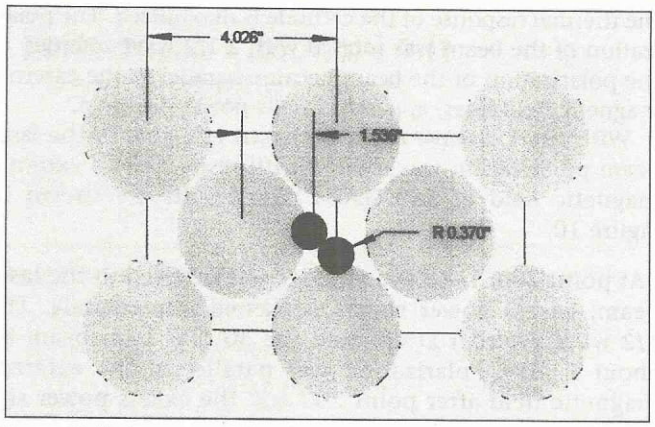

Figure 12. Hydrogen in surface palladium lattice; scale: 1" = 1 angstrom.

well. The lattice parameters of deuterated palladium are well known, as is the palladium-hydrogen equilibrium distance. The quantum well dimension is then

L = beta phase lattice parameter – 2* Pd-D equilibrium distance
= 4.026 Angstroms – 3.072 Angstroms
= .954 Angstroms.

The quantized energy levels for deuterium localized in the quantum well of dimension L are computed according to

$$E_{final} := \left(N_x^2 + N_y^2 + N_z^2\right) \cdot \frac{h^2}{8 \cdot mass \cdot L^2}$$

$$E_{initial} := \left(1^2 + 1^2 + 1^2\right) \cdot \frac{h^2}{8 \cdot mass \cdot L^2}$$

h is Plank's constant, mass is the mass of deuterium, and L is the dimension of the quantum well. The laser wavelength that is resonant with the energy difference between the two states shown above is computed as (c is the speed of light)

$$\lambda := \frac{h \cdot c}{\left|E_{final} - E_{initial}\right|}$$

The N's shown in the final energy equation can be selected so that the laser wavelength is in the red laser range. There are only a few sets of numbers that will work; quantum numbers of (10,8,1) or (12,4,2) will yield resonant laser wavelengths of 679.91 nm and 684.83 nm respectively. In practice, L is adjusted to allow for the thermal expansion of palladium. Cell temperatures of 65°C are normally encountered and serve to increase the resonant wavelength because the quantum well is enlarged by thermal expansion. With thermal expansion considered, the resonant wavelengths computed in practice would become 682.36 nm and 686.60 nm. These wavelengths can be realized from an off-the-shelf diode and tuned with a laser controller such as the ILX 3722b. The diode is cooled or heated to change the wavelength of the diode. The tuning range is typically 5 nm. Other quantum numbers can be selected to produce resonant wavelengths in the range of all standard red laser diodes: 635 nm, 650 nm, 660 nm, 670 nm, and 680 nm. All of these ranges have been tested except the 635 nm diode. There are two resonant wavelengths within each range—all diodes tested have been shown to produce excess power when they are directed onto a cathode fabricated according to protocol, loaded with deuterium, plated with gold and tuned to the specific resonant wavelengths. Omission of any one of these four requirements generally prevents the laser from triggering an excess power signal.

Discussion

The important point of this work is that it appears to be reproducible when all of the specifics are rigorously followed. For example, the cathode preparation includes many steps that may or may not be necessary—however they are sufficient for the effect. There have been multiple experiments with cathodes prepared in other ways; however, such experiments did not give consistent results.

The lack of reproducibility has been a recurring problem in this field. One key goal of these experiments has been to achieve consistent results instead of maximizing excess heat. Another goal has been to achieve conditions which will trigger the immediate release of excess power. This is important since it avoids some systematic errors such as slow variation in the calorimeter "constants."

A very useful feature of laser stimulation is that it allows for specific areas upon a single cathode to be investigated without undo interference. Several experiments have shown that the magnitude of excess heat release is dependent on the location of the laser spot upon the cathode. This opens the door to many future studies on surface conditions required for heat production.

It is hard to conceive of any error that leads to variation in excess heat as the beam's polarization is changed. The effects from external magnetic fields and beam polarization have not been investigated enough to come to a clear understanding of their roles. However, the fact that heat production from some runs varies with changes in polarization hints at some deep underlying events. This promises to be a fruitful tool to understanding some of the mechanisms involved.

Most experiments were conducted to check the variation of excess heat as the frequency was varied within a part of the red area of the visible spectrum (630 to 680 nm). This range was mainly chosen simply because of the cost and availability of narrow frequency sources. It is envisioned that the effect may be more robust for sources nearer the more populated ground states of the system. The preliminary theoretical model given above was developed to try to explain the frequency dependence seen experimentally. The important point is not the model itself but the experimental fact that the effect is seen to depend on frequency; investigators must make attempts to select laser frequencies with regard to cathode temperature when attempting replication.

This approach promises a vast array of experimental approaches since it allows for site selection, external triggering of events, application of external fields, and a specific frequency response of heat release mechanisms.

Conclusions

Laser stimulation of deuterated metals is a new and powerful method, which promises a wealth of new experimental approaches to probe the mechanism of anomalous heat. Its ability to select surface sites allows for probing variation in

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metal surface conditions that are important for the mechanism. Its frequency and polarization specificity may reveal internal mechanisms involved in heat production. Its ability to trigger heat allows avoidance of some troubles normally besetting calorimeter measurements. Much work remains to optimize the approach, but it is hoped that laser stimulation will become a powerful tool in understanding the heat releasing mechanism in deuterated systems, which now seems so inexplicable.

Acknowledgements

Special thanks to Richard and Linda Schmitz of Optima Precision, Inc., West Linn, Oregon for laser equipment and helpful consultation.

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About the Authors

Dennis Letts received his undergraduate degree from Texas Tech University in mass communications in 1972. Graduate studies in accounting and finance were at the University of Texas at Dallas 1976-78. Advanced math courses were later taken at the University of Texas at Austin plus a few courses in basic physics. Letts began studying cold fusion in 1989. Experimental work began in 1992 and has continued full time until the present. Letts has performed approximately 6,000 experiments from 600 cells. His main research interest has been triggering methodology, beginning with RF in 1992 and has evolved to laser stimulation in 2003. His work is performed in his personal lab and shop located in Austin, Texas, where he has enjoyed productive collaborations with Dennis Cravens, Ed Storms, and Scott Little for many years.

Dr. Dennis Cravens received his undergraduate degree from Abilene Christian and his Ph.D. from Florida State in 1977. He is semi-retired from teaching both college chemistry and physics. He currently teaches a few online courses from Southern Christian University and for Eastern New Mexico University. He has written both classified and unclassified studies for the DOD in the area of innovative physical methods for energy and propulsion. He is on the Scientific Advisory Board for *Infinite Energy* and has been active in the area of cold fusion since 1988. His main research interests involve trying a wide variety of cold fusion methods to find common mechanisms and understanding. His work is done in his own private laboratory in Cloudcroft, New Mexico.

*E-mail: lettslab@austin.rr.com
**Email: Physics@netmdc.com; Dennis.Cravens@enmu.edu

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A Search for Anomalies

William R. Corliss*

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Introduction

Since 1965 I have been culling systematically from the literature of science those observations that challenge reigning paradigms. The tangible result of the thousands of hours spent in libraries has been a series of Sourcebooks, Handbooks, and Catalogs that, at present, describe and evaluate roughly 2,000 anomalies—about one-half of my total collection. Some of these anomalies are truly profound and have important implications for science, such as the quantization of astronomical redshifts; others are less significant, as is the recent discovery of that curious little door in one of the Great Pyramid's "air-shafts." Overall, this immense accumulation of anomalies will hopefully encourage new research projects, some paradigm shifting, perhaps even the emergence of yet-undreamed-of hypotheses that will better describe nature.

This historical essay begins in 1951 with my astonishment at my unexpected discovery that important scientific anomalies not only exist but also are pervasive and abundant in the professional journals. The essay continues with the translation of these two epiphanies into the Sourcebook Project and the thirty-six books on anomalies that it has published so far.

This is largely a personal story and is therefore told in the first person. I believe this saga, conducted mostly in libraries, will be relevant to anyone who has also perceived some of the multitudinous cracks, big and small, so obvious in the foundation of the Temple of Science.

The Pivotal Role of Serendipity

The Sourcebook Project really germinated in 1951 in an unexpected manner. To begin my search for anomalies, I first had to learn that they existed—a reality not broached in the usual college science curriculum. I came across anomalies by accident.

In 1951 I was working on the 184-inch cyclotron at the Radiation Laboratory of the University of California. On a day off, I happened to pick up for $2.00 in one of Berkeley's bookstores a used copy of George McCready Price's 1926 book, *Evolutionary Geology and the New Catastrophism*. That the word "catastrophism" would appear in the title of any geology book was shocking in those days, for uniformitarianism was dominant in the earth sciences. I do not recall my geology professor ever mentioning "catastrophism"! Even more surprising were Price's field observations that challenged what I thought were well-established truisms. To illustrate, Price pointed out many places on the planet where older rocks are superimposed upon younger rocks; for example, at Chief Mountain in Montana. There, an entire mountain of older rock rests upon much younger sediments. Price's book contained many more geological anomalies, some of which are now explained but many more that are not. So it was George McCready Price, who would today be called a creationist, who first made me aware that anomalies exist, at least in the field of geology.

My second unanticipated discovery made me realize that anomalies were common in *all* branches of science. This happened in 1953 in the library at the University of Colorado when I was trying to find out what was known about the solar spectrum in the far ultraviolet. (The Physics Department had spectro-grams of the sun taken at high altitudes during flights of captured V-2 German rockets.) Right next to a book I desired was Charles Fort's *The Book of the Damned*. Naturally, I had to take out that book, too. It turned out to be chock full of anomalies of all sorts, all of which Fort had extracted from major science journals prior to 1930. Fort designated these anomalies as "damned" because they were generally ignored by mainstream science. Fort's book concentrated on astronomy and geophysics. I was particularly intrigued by the examples of those strange explosive sounds heard in coastal regions around the world. The Barisal Guns in the Ganges Delta are perhaps the most famous. Around the coast of the North Sea, they are called "mistpouffers" or "fog guns." It was all certainly very fascinating, but I had to finish my education and start making some money for my family. Nevertheless, I now knew that scientific anomalies not only existed but were also spread throughout all of science.

Serendipity struck again a decade later. By 1963 I had become disenchanted with industry and had started a career in freelance writing. (My wife said she would give me five years to make a go out of it.) Fortunately, I had a head start. I had already written a book on space propulsion, based on a course I taught at General Electric in Cincinnati, which had been published by McGraw-Hill.[1] This helped me get writing contracts with the National Aeronautics and Space Administration (NASA), the Atomic Energy Commission (AEC), and the National Science Foundation (NSF). These efforts took me frequently to Baltimore's Enoch Pratt Free Library. These visits gave me the opportunity to verify some of the anomalies I had read about in Fort's *The Book of the Damned*, especially those curious mistpouffers! As I leafed through the pages of *Nature* circa 1898–1900, I found that Fort's research had been accurate but rather narrow. He had missed a lot of anomalies. Fort, it seems, was not particularly interested in archeology, geology, or biology. He had not even picked up on all those intriguing British stone circles, which were a favorite subject of Norman Lockyer, the editor of *Nature* around the turn of the century.

Thus, it was once more made obvious to me that anomalies were ubiquitous and present in greater numbers than I

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had dreamed. Fort had been selective and had explored only part of the science literature and then only up to about 1930. There was a whole universe of anomalies waiting for me in the dusty stacks of Baltimore's main library and the easily accessible Library of Congress.

At this point in the history of the Sourcebook Project (which hadn't even been christened yet), there was no thought of making a business out of anomalies. I first had to satisfy NASA, AEC, and NSF. Between 1963 and 1981, I wrote thirteen books for NASA on space flight,[2-4] a dozen educational booklets for AEC, and the same number of articles for *Mosaic*, a now-discontinued, bimonthly magazine published by NSF. There were also several books written for New York publishers, including one I coauthored with Glenn Seaborg.[5]

A point to be made here is that a freelancer usually has extra time now and then to turn to other projects of interest; in my case, anomalies. And in the back of my mind, as you would expect in a writer, was the possibility of a book on anomalies. Something like *The Book of the Damned*, but updated and wider in scope. Because this book, or possibly a series of books, would be ferreting out and organizing anomalies from a wide spectrum of sources, I decided to name the venture The Sourcebook Project.

Curiosity-Indulgence and Profitability

In 1965, the major goal of the nascent Sourcebook Project was to satisfy personal curiosity. Such indulgence costs little, but to probe the unknown deeply and widely and then publish the anomalies uncovered requires more than casual interest. Organization, infrastructure, and funding are required. The present Sourcebook Project—still only a one-person endeavor—took twenty years (until 1985) to coalesce into a self-supporting enterprise. The profitability motive that was and still is absolutely essential to Project viability has necessarily produced an operating philosophy that differs somewhat from most other inquiries into the nature of the cosmos. I had and still have no institutional funding or infrastructure. This disconnect from most mainstream science efforts can be seen in the following three objectives that guide Sourcebook Project activities:

1. The primary objective of the Project has always been that of satisfying the curiosity of the author. This proclivity stimulated the search for anomalies and has sustained it for almost four decades. This innate curiosity has been vital because the financial rewards would have been much greater in my first career in engineering management.

2. Secondly, the Sourcebook Project must be self-supporting financially and develop its own infrastructure. As in any business, viability is one of the primary goals. This commercial focus had to exist because government, foundation, and private support have never been deemed likely. This premise has proven correct over the last four decades.

3. The third objective is the only overtly altruistic one. That is the potential value to science of the information acquired through the thousands of hours in libraries and its consolidation into accessible form both in books and CD-ROMs.

The Search and Collection

Beginning in the mid-1960s, every time I visited a library, I spent an hour or two combing through old volumes of science journals. The obvious place to begin was with the major general-science journals *Nature* and *Science*. Every one of the hundreds of volumes of each of these two journals was scrutinized for anomalies. I moved next to *American Scientist* and science magazines such as *New Scientist* and *Scientific American*. There were also the major specialized journals to attend to: *Geology, Monthly Weather Review, Icarus, American Journal of Psychiatry, Antiquity*, etc. Over the years, some 15,000 volumes of major science publications have been examined.

The identification and collection of anomalies was (and still is) a rather tedious task. The reward is that every trip to a library adds new anomalies to the burgeoning collection. It is a bit like fishing; boring most of the time until the big one bites! Obviously, I did not read every word of every article. Title pages were helpful. My eyes were peeled for key words like "enigma," "mysterious," "puzzling," "unsolved," "singular," and so on. The word "anomaly" was rarely used in the 1960–1990 time period in its present sense. Without question, I have missed many anomalies in my surveys. Some of these were discovered later when reference lists and relevant books were analyzed. Reviewers have pointed out others.

Nature has been far and away the most useful general source. Its productivity, though, has changed with its editors. The *American Journal of Science*, founded in 1820, was a gold mine of anomalies of all sorts in the beginning. Now, 400 volumes later, it publishes mostly long, highly technical articles on geology and rarely provides me with new material. *Science*, too, has been variably useful. To illustrate: In its infancy, *Science* did not avoid parapsychology because its editor at the time, Simon Newcomb, like many prominent scientists in the late 1800s, did not discount psychic phenomenon.

Bit by bit my anomaly collection grew. Unlike Fort, who had to jot down telegraphic (often unreadable) notes about phenomena, I had access to photocopiers. Today, my files bulge with perhaps 50,000 articles, letters, and brevia dealing with anomalies. I now estimate my collection holds about 4,000 distinct anomalies. This number could easily be increased simply by spending more time in libraries and tackling the thousands of unscanned journals.

To appreciate what I have been extracting from the science literature, see the Appendix for a selection of about 100 anomalies from my files. Then multiply by forty!

By 1972 I had enough material on hand to think about publishing some of it. I knew that no commercial publisher would sign on to a series of perhaps two dozen books. Just as certainly, no government agency or foundation would want to commit to such a long-term, controversial project. (While I was doing contract writing for NSF, discreet inquiries had validated this conclusion.) My decision was to self-publish my collection of anomalies and try to make it a profitable enterprise to boot.

The Sourcebook Project has evolved in three phases, although the last two phases were not in the original plan.

Phase I. The Sourcebooks

In 1974, as an experiment, I began self-publishing a series of ten loose-leaf notebooks called "Sourcebooks." The name was apt because they contained direct quotations from the older science journals with minimum interpretation and commentary. The first two volumes, entitled *Strange*

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Phenomena I and *Strange Phenomena II*, typify the set. They collected and categorized many of the geophysical anomalies I had gleaned from the literature. I engaged John C. Holden, a well-known science illustrator, to provide drawings for some of the phenomena. I continued the series with two volumes on archeology (*Strange Artifacts I* and *Strange Artifacts II*). Between 1975 and 1978, Sourcebooks in the fields of geology, astronomy, biology, and psychology came off the press. Even though the Sourcebooks are now some twenty years old, a few orders for them still trickle in. About 30,000 copies have been sold over the years.

Of course, orders for the Sourcebooks did not sell without some advertising effort. I used commercially available mailing lists and a few half-page display ads in *Science, Nature, Science News*, and a small handful of other science journals and magazines. Interestingly, the most productive ad appeared in *Sky & Telescope*. Individual books in the series were reviewed in *Nature, American Scientist*, and several other publications, including (to my astonishment) the *Village Voice*. These reviews obviously helped sales.

The Sourcebooks differ markedly from the books of Charles Fort (*The Book of the Damned* was the first of a series of four). The material in the Sourcebooks is organized by subject and dispenses with the many brickbats tossed at science-in-general by Fort. The Sourcebooks are not confrontational but rather matter-of-fact quotations from the journals with minimum commentary.

Phase I of the Sourcebook Project was financially successful, but not enough so as to sustain my family and put four children through college. In the 1970s, I continued to write, mainly for NASA, under contract. The resulting books were published by the U.S. Government Printing Office and, in a few cases, by commercial publishers under contract to NASA. One, entitled *Teleoperators and Human Augmentation*, was republished commercially. The last book I wrote for NASA was published in 1981, bearing the title *Wind Tunnels of NASA*.

The Sourcebooks, it turned out, had an unacceptable deficiency from the viewpoint of many libraries. They were ringbound, and the pages could be and were removed by library clients. I could have gone on generating dozens of additional Sourcebooks, but to satisfy the library market, a new strategy was required.

Phase II. The Handbooks

Basically, the Sourcebooks were converted into hardcover books, but with more commentary, newer material, and many additional illustrations. The first Handbook, *Handbook of Unusual Natural Phenomena*, was self-published in 1977. The response was very encouraging with more good reviews in key science and library journals. In fact, the book caught on so well that Doubleday asked me to write a popularized version for them. This version appeared first as a quality paperback in 1983. It was later republished in hardcover form by two other publishers. Approximately 100,000 copies were sold altogether.

In the meantime, the other five books in the Handbook series were being self-published. The second in the series, *Ancient Man*, has been reprinted several times and is still one of the Project's best-sellers. The final Handbook, *Unfathomed Mind*, came out in 1982. It is now out of print.

Like the Sourcebooks, the Handbooks were marginally rewarding financially, and they were still fundamentally only reproductions of anomaly descriptions derived from the science literature. Background and significance were usually lacking. Furthermore, new anomalies were being added to the files at such a rapid rate that a new format was needed to accommodate this influx. More importantly, something had to be added to the books that indicated the potential impact of each anomaly and the quantity and quality of the observations that supported it.

Phase III. The Catalog Series

The "Catalog" concept goes far beyond the simple republication of the anomalous observations that characterize the Sourcebooks and the Handbooks. In the Catalogs, anomalies are singled out, closely defined, and then evaluated in terms of the quality of supporting data and how challenging they are to mainstream paradigms. Quotations from the original sources are still employed, but they are shorter. More space is devoted to the background of the phenomena. I include examples of the anomalies and many references to aid future researchers.

The catalog volumes are more focussed than the Handbooks. For example, the four geophysics Catalogs are specialized as follows:

- Luminous phenomena
- Weather phenomena
- Atmospheric-optics phenomena
- "Oscillatory" phenomena (*i.e.*, waves, tides, sound, earthquakes, etc.)

The four Catalog volumes in geophysics were published by the Sourcebook Project between 1982 and 1984. (All Sourcebook Project publications in print are listed on my website: www.science-frontiers.com.)

The Catalog concept advanced with three volumes on astronomy between 1985 and 1987. Geology came next, then biology and archeology. Roughly one Catalog volume has been published each year. As of 2002, there are twenty catalog volumes on the shelf. The task, however, is far from over. I contemplate six more volumes in archeology and three in psychology. Some time, I hope to return to biology, where the six extant volumes deal only with humans, the other mammals, and birds. I have immense, unused files on reptiles, fish, the arthropoda, plants, invertebrates, microorganisms, genetics, etc. Once I had hoped to complete the Catalog series in twenty-five volumes. Now, a total of thirty-five seems probable. The universe of anomalies has turned out to be expanding like the cosmos itself.

On the economic front, the Catalogs have kept the Sourcebook Project solvent. Reviews have generally been very favorable. To maintain sales volume, I have relied mostly upon word-of-mouth and a mailing list developed over thirty-five years. My bimonthly mailings feature my newsletter, *Science Frontiers*, plus advertisements for related books by other publishers. Display ads and commercial mailing lists are now too expensive to employ. Happily, the Internet has come along and my website has made up for the abandoned display ads and mailing lists.

So much for the business aspects of the Sourcebook Project. Book marketing has made the Project viable and kept it free from the vicissitudes of commercial publishers and the dictates of institutions.

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Sourcebook Project Interfaces

The Sourcebook Project has never solicited members, just customers. It is strictly a business without narrow philosophical or political goals. Over the years, though, some interesting interfaces with other organizations have developed.

Fortean Groups

Relations have always been amicable with the International Fortean Organization (INFO), the Society for the Investigation of the Unexplained (SITU, publisher of *Pursuit*), and the UK's *Fortean Times*. Although Fort's methodology has been valuable in developing the Sourcebook Project, I have tried to avoid the Fortean tendency to ridicule established science. Such bizarre and improbable Fortean phenomena as pyramidology and psychic archeology have generally been avoided. Indeed, the Project has been criticized as not being sufficiently Fortean; that is, not bizarre enough. This is quite true and can be explained by my almost total dependence upon mainstream science literature for source material. Newspapers are rarely used, the Internet is avoided totally. I very rarely use fringe magazines and the personal accounts that frequently turn up in the mail.

As a result, perhaps, there are only a few dedicated Forteans on my customer list. Velikovskians, too, tend to ignore my self-published books, as do the cryptozoologists, ufologists, and those into psychic phenomena. However, the Sourcebook Project also carries roughly 100 books from other publishers. These cover topics usually excluded from my Catalogs, such as Atlantis, intelligent design, the yeti, and even magic squares and humor.

Creationists

An interesting, informal, reciprocal interface prevails between the Sourcebook Project and the various creationist groups. The Catalogs and Handbooks, for example, contain much of interest to creationists in the fields of biology and geology. This occurs because I have amassed reports of phenomena that apparently challenge neo-Darwinism. Flowing in the other direction are observations that creationists have discovered in journals that I do not have the time to monitor. In addition, some individual creationists are particularly adept at finding flaws in widely accepted science paradigms, such as the continuity and integrity of the geological column and the utility of so-called vestigial organs.

In this context, I emphasize that the Sourcebook Project intends to be value-free. Let the facts fall where they may! This Fortean skepticism about the value of theories-in-general doubtless annoys both creationists and their opponents. Theories are ephemeral, but facts live forever.

The Skeptics

One would expect a lively interface between the Sourcebook Project and the several groups of skeptics, as typified by the Committee for the Investigation of Claims of the Paranormal (CSICOP). After all, my Catalogs do challenge those paradigms the skeptics defend so ferociously. Actually, there has been no traffic whatsoever in either direction. While mainstream *Nature* has reviewed five of my books, the skeptics have shown no interest in evaluating any of the Sourcebook publications. The skeptics, it seems, are never skeptical of *established* paradigms, only those observations that threaten to disestablish them.

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The Media

The results of contacts with talk radio, TV programs, and newspapers have been disappointing. Since 1990 I have rejected all invitations for interviews and media events. The major factors in keeping the media at arm's length are their tendency to distort facts and not allow my review before publication or airing. Invitations from major publishers to write books on anomalies are now routinely turned down but usually for a different reason: It is more profitable and satisfying to self-publish and be able to control the format, content, and market-longevity of my books.

Mainstream Science

Early on, I hoped that experts in various disciplines would be interested in providing information or at least comments on drafts of material before publication. This interface was never established. Of course, a scientist's time is valuable and I cannot be considered a "colleague"! The Sourcebook Project is hardly part of the scientific community. There have been a few individual exceptions, but the reaction of mainstream science has been mainly via book reviews (generally favorable) and occasional references to my books in the journals. Some scientists do purchase books from the Project, including even some Nobelists. Generally speaking, though, mainstream scientists are not good customers, despite the good reviews and several selections by book clubs.

Some General Observations

Who, then, does buy enough books to keep the Sourcebook Project in the black? Tests with ads and mailing lists indicate that it is not the Forteans, the creationists, the UFO crowd, the cryptozoologists, the parapsychologists, the Velikovskians, subscribers to *Fate*, or mainstream scientists. In fact, as Henry Bauer indicated in a recent *Journal of Scientific Exploration* (*JSE*) editorial,[6] it is not members of the Society of Scientific Exploration (SSE) either. My theory is that each of the groups mentioned contains only a few "general-anomalists"; that is, individuals whose interests are much broader than those of the group they are associated with. The Sourcebook Project has tapped this dispersed population and is thus able to survive.

It may be of interest to SSE members that only about 2% of them are on my mailing list, which length-wise is somewhat larger than the SSE membership list. This surprisingly small figure is also typical of members of Fortean groups, in fact, of *all* the speciality groups mentioned in the previous paragraph.

Despite its charter, I believe the SSE is composed mainly of several small groups of specialists, with only a few generalists. That this may be so can be seen by comparing the sub-

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I have also noticed that scientists who specialize (and most do) will readily admit that anomalies exist in their fields of endeavor. In fact, they sometimes take pains to point out anomalies that I somehow missed in my literature research. However, these same scientists are often reluctant to admit that *all* other branches of science also exhibit anomalies.

ject matter in the Tables of Contents of several issues of the *JSE* with the topics listed in the Appendix. I see a wide disconnect between the two lists of topics. But it may be that those submitting articles to the *JSE* are not typical of the membership as a whole. I don't know.

Many of my customers also come from the general population of people with scientific training and interest, but who are not in academia or members of the speciality groups mentioned above. Medical doctors and engineers are perhaps the most prominent in this regard.

Over the years, the archeology books offered by the Sourcebook Project have sold the best; those on parapsychology, the worst. In contrast, articles with a slant toward parapsychology are frequent in the *JSE* while archeology articles are nearly nonexistent.

I have also noticed that scientists who specialize (and most do) will readily admit that anomalies exist in their fields of endeavor. In fact, they sometimes take pains to point out anomalies that I somehow missed in my literature research. However, these same scientists are often reluctant to admit that *all* other branches of science also exhibit anomalies. A scientist who admits the possibility that Nessie lives will not doubt the reality of the expanding universe. A scientist favorable to UFOs will not question neo-Darwinism.

Scientists, like everyone else, prefer a broad, stable frame of reference, one without too many unknowns and uncertainties. But the Sourcebook Project claims that thousands of anomalies pervade all fields of knowledge. This assertion may be a little too unsettling to many.

Conclusions

The long hours spent in the dusty library stacks have proven intellectually rewarding to me. I intentionally avoid theorizing about what I have found over the past forty years, for that would taint the objectivity of my continuing search. I claim only that there are a lot of anomalies out there, and that there are many more that I have not yet added to my collection. Every week the science journals bring new mysteries into my ken. I collect them like a philatelist does stamps. For every anomaly I have to remove from my album as having been explained, two new ones arrive to take its place with the next delivery of mail.

Anomaly-collecting is obviously not science, for it assiduously eschews theories and the testing of theories. As I see it, the value of the Sourcebook Project to science is in its long lists of potential research areas. These lists demonstrate that science is far from complete. The Handbooks and Catalogs have the potential to stimulate the progress of science—and that is good. The more anomalies that are recognized, researched, and explained, the more accurate is our picture of the universe.

Appendix: A Few Selected Anomalies

Archeology

1. The "pit bands" of the Andes. The pits are about a meter deep and arranged regularly in bands about 24 meters wide. The bands run along the ridges for miles.
2. The stone meanders and labyrinths of the western U.S.
3. Boulders with triangular holes. Called "Viking mooring stones," there are hundreds in northeastern U.S.
4. Hundreds of large precision-crafted stone spheres in Costa Rica. These are near-perfect spheres made of hard granite!
5. The East Bay and Point Reyes walls, California. Builders and purpose unknown.
6. Incan stone masonry. Interlocking, precision-fitted, multi-ton stones, some with many corners.
7. Ancient Baalbek's massive, dressed Monolith, in Lebanon (weight: 1,100 tons).
8. The enigmatic stone blocks at Tiahuanaco (Bolivia) and at least one Inca site. These are huge, geometrically complex, fashioned out of hard rock, and seem to have no discernable purpose.
9. Scotland's ancient vitrified stone forts. (How did they melt granite?)
10. Enigmatic structures within the Great Pyramid. Examples: so-called air passage with secret door, sand-filled cavities, layered granite beams in King's Chamber, the mysterious sliding plugs, and several more really perplexing structures.
11. Ancient skeletons in North America with Caucasoid features, such as Kennewick Man, and others less-famous.
12. Trans-oceanic, pre-Columbian diffusion of plants and their products. Examples: maize to India, cocaine to Egyptian pharaohs, cotton, pineapples, and many more.
13. The Nazca lines, Santa Valley geoglyphs, and the huge Candelabra of the Andes—the latter visible from far out at sea!
14. Near-global existence of the cup-and-ring motif in old petroglyphs.
15. The ability of the ancient Egyptians to fashion narrow-necked, hollow vases out of obdurate granite with only copper tools. Also relevant, the precisely made, polished, multi-ton granite slabs in the Great Pyramid.
16. Mysterious Olmec origin. Their articles display apparent Chinese symbols and cultural characteristics.
17. Miniature buildings at some Maya sites and miniature subterranean tunnels (*i.e.*, much too small for normal humans)!
18. The famed Baghdad battery
19. The ancient Greek analog "computer."

Astronomy

1. Anomalous split of angular momentum between the sun and the planets. Most of it is in the planets.
2. Comet flare-ups far from sun. (Only supposed to happen close to sun.)
3. Historical record of bright objects appearing close to the sun. (Vulcan, the intramercurial planet.)

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4. Mercury's puzzling high eccentricity, inclination, and its unexpected and offset magnetic field.
5. Anomalous transits of Jupiter by the Galilean satellites. Double shadows thrown on Jupiter; "hot" shadows, dark transits.
6. Lunar concentrations of mass (mascons), magnetism (magcons), radioactivity (radcons).
7. Transient Lunar Phenomena (TLPs). (Flares, color changes, obscurations, etc.)
8. Martian surface asymmetry. Half the planet is highly elevated; half, low.
9. Magnetic stripes on Mars.
10. Globular-cluster enigmas. (Great age, non-participation in galaxy motion, etc.)
11. Anomalous accelerating expansion of universe.
12. Anomalous precession of DI Herculis. (Challenges Einstein)
13. Quantized redshifts. Puts expanding-universe paradigm at risk.
14. Source of ultra-high-energy cosmic rays.
15. Absence of antimatter in universe. Should be as common as normal matter.
16. Anomalous rotation of galaxies implies existence of so-called "dark matter."
17. Discordant redshifts. Some objects, seeming physically connected, have radically different redshifts. (Halton Arp's heresy!)
18. Meteorite distribution anomalies. Concentrations in Antarctica and on Australia's Nullarbor plain. The "Iron Alley" in U.S., etc.
19. Antarctic meteorites differ markedly from those picked up elsewhere.
20. Meteors seen at altitudes so high that there should not be enough air-friction to make them visible.

Biology

1. Avian feather-pattern-generation mechanisms not understood. Also applies to colorful seashells, butterflies, and other patterned organisms.
2. Inherited callosities in birds, such as the Ostrich.
3. Physiological convergence of Arctic and Antarctic birds, especially the alcids. They look alike but are not closely related.
4. Brood-parasitism anomalies, as in mimicry of appearance and voice by nestlings.
5. Unknown mechanism of inheritance of instincts. How is migratory information passed on genetically to young birds travelling without parents? (Example: the bronzed cuckoos of Australasia.)
6. Avian "courts" and executions.
7. Unique, complex respiratory system of birds completely unlike any suggested ancestors.
8. Avian homing and navigation feats. Examples: homing pigeons and Arctic Terns.
9. Disturbed human behavior correlated with sun and moon.
10. Human intelligence correlated with birth-order and season of birth.
11. Anomalously large number of breaths and heartbeats per human lifetime as compared with other mammals.
12. Rapid, quantized growth spurts in human children.
13. Lack of biochemical value in human sleep.
14. Human mitochondria vastly different from those in other mammals.
15. Immortality of cancer cells.
16. Higher cancer incidence correlated with greater organism complexity. Why?
17. Fetal-graft enigma. Why does immune system not reject fetus?
18. Presence of much subcutaneous fat in humans as in many marine mammals. (The aquatic-ape theory.)
19. Experimental lack of memory traces. How is information stored in brain?
20. Human navigation sense. Human homing experiments.
21. Human diving reflex and, contradictorily, drowning proneness.
22. Parasite manipulation of human behavior. (Same for other mammals, birds, etc.)
23. Limits on the variability of domestic animals. No new species in breeding experiments. A big Darwin worry.
24. The puzzle of flavor aversion, especially in rats.
25. Deliberate use of medicinal plants by non-human mammals and birds.
26. Survival of the thylacine (marsupial wolf). (Some pretty good data here.)
27. Inheritance of the behavioral effects of rotation in rats.
28. Plants mimicking other plants even though they lack eyes. (Example: some mistletoes.)
29. Fishlike lures evolved and used by mussels, snapping turtles, and other species.
30. Worldwide synchronous flowering of bamboos.
31. Selfish DNA (or genes or viruses or proteins): the ultimate parasites.
32. Interplant communication ("tree-talk," for example), especially via air-borne chemical signals.
33. Directed-mutation experiments
34. Unknown cause of the Cambrian explosion of new life bauplans; (*i.e.*, new phyla).

Geology

1. Controverted source of deep-focus earthquakes.
2. How are concretions formed? They exist in bizarre shapes in untold numbers.
3. The surprising existence of life at great depths in the earth's crust; that is, in the crevicular domain.
4. Unexplained origin of dolomite, some limestones, methane-hydrate deposits, and several other types of sedimentary rocks. The dolomite problem has bothered geologists for 100 years!
5. Coal anomalies. (Examples: anomalous fossils, frequent absence of plant fossils and vegetable structure, coal beds 50 feet thick and more present over wide geographical areas, and many more.)
6. Cyclothems and rhythmites. Repetitious strata, sometimes hundreds of thousands of layers.
7. Polystrate fossils, especially vertical tree fossils penetrating millions of years (supposedly) of deposits, as at the Joggins formation in Canada.
8. Oriented lakes (Alaska) and the famed Carolina bays, the latter present in hundreds of thousands—all oriented. A meteor storm?
9. Cookie-cutter holes and resulting giant divots. Surprising number of these.
10. Several examples of devastated areas, especially in Brazilian jungle, suggesting recent Tunguska-like impacts.
11. The missing crater associated with the immense deposit

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of Australites (tektites). Given the extent and quantity of these tektites, there should be an immense, 700,000-year-old crater somewhere.
12. The famous mima mounds. Present in incredible numbers. How created? Some say "pocket gophers"!
13. Giant expansion-and-contraction polygons in soils. Hard-to-explain long-range order.
14. "Missing" strata at Grand Canyon and associated anomalies of formation.
15. Ancient, *uneroded*, elevated plains. Why no erosion over the eons?

Geophysics
1. Ball lightning in its many guises.
2. Luminous bubbles in the atmosphere. Too many observations to dismiss offhand.
3. Earthquake lights. Abundant observations, especially from Japan. Mechanism uncertain.
4. Cold, ground-level flames and lights. (Will-o'-wisps) Not really explained completely.
5. Marine light wheels. One of the great unexplained phenomena. (Hundreds of sound observations.)
6. White water or milky seas. Here, too, we have hundreds of good observations.
7. Shadow bands during solar eclipses. Many anomalous appearances; for example, giant bands, colored bands, bands moving in the wrong direction.
8. Conical hail, bizarrely shaped hail. These objects are reproduced and fall by the millions. The creative mechanism is unknown.
9. Hydrometeors. Some are from aircraft but others seem to be extraterrestrial.
10. Brontides and mistpouffers. Examples: Barisal guns, Lake Seneca guns, etc. Some are due to small methane-hydrate blowouts, particularly those in North Sea.
11. Sound of the aurora. Sounds from high-altitude meteors. Both species are thought to be electrophonic sounds. Also, some people "hear" radar pulses!
12. Rainbows with offset white arcs. They defy optical theory.
13. Offset solar halos and anomalous arcs. Also unexplained.
14. Sea seiches and "death waves." These are not tsunamis.
15. Transient all-sky brightenings. Good observations. Some are probably meteoric, others are unexplained.
16. Mountain-top glows, such as the famed Andes Lights. Often associated with seismic activity.
17. Luminous cores of some tornados. Probably related to the electrical effects of some strong tornadoes, as in burning and dehydration along paths.

Psychology
1. The break-off phenomenon experienced by pilots.
2. Why do we need to sleep and dream?
3. Mathematical, calendar, and musical savants.
4. Genius correlated with mental illness!
5. Eidetic imagery. Usually lost in adulthood, but can sometimes be restored by hypnosis.
6. Exceptional and photographic memories
7. Synaesthesia. Comes in many forms. Usually numbers or words and rendered in different colors.
8. Results of reincarnation research. Many examples from India of accurate memories of past lives, birthmark phenomena, etc. Can't really dismiss completely.
9. Hypnosis and its effect on color blindness.
10. Death and the "birthday phenomenon."
11. Phantom-limb phenomena. Many anomalies here.
12. Stigmata.
13. Blister-raising and skin-writing via hypnosis.
14. The Princeton experiments in psychokinesis.

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About the Author

Mr. Corliss received a B.S. in Physics from Rensselaer Polytechnic Institute in 1950, and an M.S. in Physics from the University of Colorado in 1953. He has been a freelance writer and researcher since 1963, and is founder of The Sourcebook Project. Mr. Corliss is the author of sixty books, as well as dozens of booklets and articles. The author will provide a free copy of his newsletter, *Science Frontiers*, to anyone who requests it.

*Sourcebook Project, P.O. Box 107, Glen Arm, MD 21057
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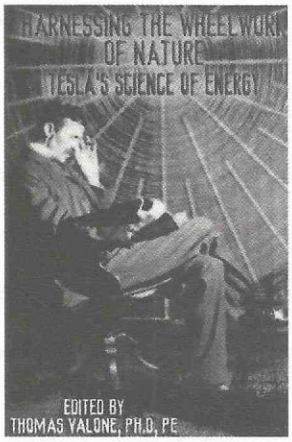

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Cold Fusion: Experiment, Theory, and the Importance of Gadolinium Catalyst

H.C. Josephs*

Background

Recently Dr. Michael McKubre *et al.*[1] presented the results of four different experiments performed at SRI International in Menlo Park, California. The most significant of these were conducted using apparatus similar to that described by Les Case.[2] Figure 1 shows the production of He-4 in six of sixteen runs over a period of forty-five days. The concentration of helium in the reaction chamber exceeded that in the ambient air by a factor of more than two. Figure 2 shows the production of excess energy and He-4 in run SC2 over a period of twenty days. Although the quantity of helium produced was only 75% of that needed to account for the energy released, the temporal correlation of the heat and helium is obvious. The deficit in the amount of helium is accounted for by the retention of the gas in the catalyst material. The catalyst material is reported to have been palladium on carbon. No mention is made of any other catalyst material having been used. When the energy released is plotted against the helium generated, as in Figure 3, the direct correlation of the two is well within the error limits. Thus, McKubre *et al.* have firmly established the validity of one cold fusion process, and the concept in general, with their clear-cut proof of the correlation of the production of heat and He-4.

These experiments have shown that nuclear reactions producing not only heat, but also helium in sufficient quantity to account for the heat, can be initiated in deuterated palladium at low energy. An obligation has therefore been placed on scientists to develop a theory which not only explains why initial efforts to verify the experiments of Fleischmann and Pons[3] generally resulted in failure, but which provides guidance as to how the process might be made more reliable and reproducible. This paper presents such a theory. Although this theory is based on established physics, certain functions and parameters need to be experimentally verified. These have been conservatively estimated or approximated and a simple model for the nuclear strong force, based on the Yukawa Potential and information extracted from the neutron cross section curves of V. McLane,[4] has been developed. The results show that there exists a sound theoretical basis for the reality of what has come to be called "cold fusion."

Some of the predictions of the theory are: 1) Palladium is the optimum host material to support a nuclear catalyst. 2) Rhodium can catalyze cold fusion, but only with erratic results. 3) Gadolinium in very low concentration in palladium is the best potential catalyst material.

The cold fusion process can serve as a useful platform for studying the various nuclear and electronic processes that take place in the solid state. Of especial interest would be the opportunities for probing the nuclear halo and evaluating the extranuclear proton and neutron energy states, known as "halo states." Perhaps, as a result of such studies, alternative materials can be discovered or developed to substitute for the precious metals which at present appear to be essential to the processes of nuclear cold fusion.

The purposes of presenting this theory are to establish that a reliable cold fusion process can take place under appropriate conditions within the bounds of known physics and to refute the arguments presented by J.R. Huizenga, Chairman of the 1989 Cold Fusion Panel.[5] The paper also presents one promising process and provides some guidance as to how experimental work could profitably proceed.

Introduction

In their announcement of March 1989, Fleischmann and Pons[3] (F&P) hypothesized that deuterons could be caused to fuse at very low relative energies by "compressing" or packing them closely together in a lattice of palladium metal. They further assumed that the results of this fusion would be similar but not necessarily *identical* to the results obtained from the traditional d-d reaction in a vacuum, wherein one

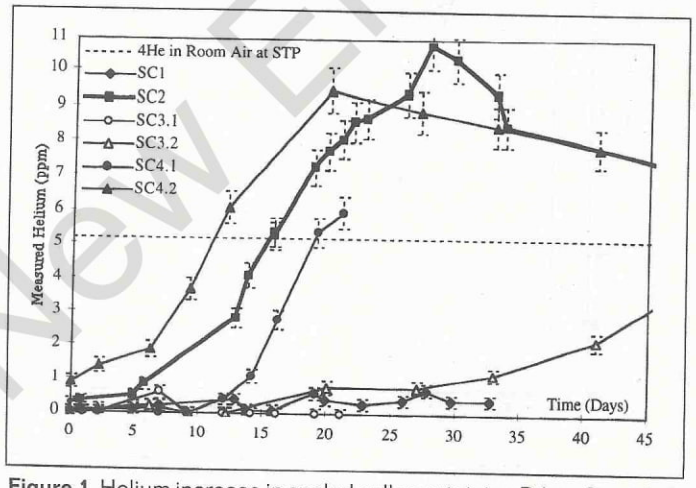

Figure 1. Helium increase in sealed cells containing Pd on C catalyst and D_2 (H2) gas. (Courtesy of Mike McKubre *et al.*)

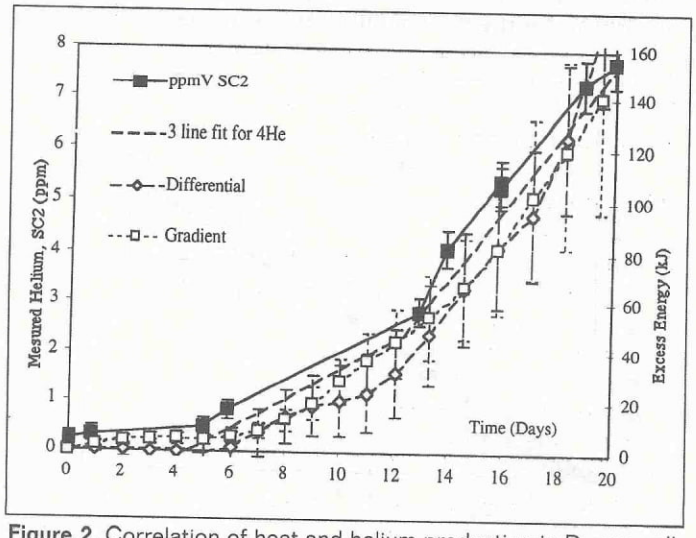

Figure 2. Correlation of heat and helium production in D_2 gas cell. (Courtesy of Mike McKubre *et al.*)

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deuteron directly impacts another with sufficient energy to overcome the Coulomb barrier, in excess of 480,000 electron Volts. The immediate response of physicists was that the first F&P hypothesis was wrong, as only a few hundredths of an eV are available at room temperature. Testing the second hypothesis led others to look for the traditional products of d-d fusion: protons, neutrons, gamma rays, tritium (H-3), helium (He-3), and heat. The reported results were sporadic, unreproducible, and insufficient despite numerous attempts to improve the reaction cross section by modifying the cathode material, electrolyte, charging time, operating current, temperature, and even magnetic field. While the evidence amply demonstrates that cold nuclear fusion does not proceed like hot plasma fusion, it does not disprove the presence of nuclear activity.

The New Theory, Briefly

In brief, the theory presented here is based on the use of a two-element metallic composition (a host metal and catalyst isotope) into which deuterium can be loaded using whatever process is best suited to the application. The method by which the deuterium is loaded is not critical, only the presence in the host metal of deuteron ions at the proper energy level is important. The host metal is chosen for its ability to absorb a large quantity of any of the three common isotopes of hydrogen and its ability to strip the electrons from the atoms of such isotopes, converting them into free and highly mobile positive ions which, in these cases, are the naked nuclei of those isotopes. The metal palladium fulfills these requirements as a host metal notably well because in its ground state the highest energy band, 4d (that is, the d subshell of the 4th shell) is filled and the next higher bands are empty. At higher temperatures the 5s subshells overlap the 4d subshell so there are many unoccupied states near the Fermi level. Although the ground state of Pd is unique, other metals such as Cu, Ag, Au, Ni, and Pt have somewhat similar electron structures and would be worthy of investigation as they are more plentiful than Pd.

The catalyst material is chosen from those elements which have one or more radiologically stable isotopes having a large thermal neutron capture cross section in an appropriate energy range.[6] Such isotopes are more to be preferred if they comprise a large percentage of the natural material and if the material itself is easily accessible. Natural gadolinium meets these requirements most notably. Gd-157, with a thermal neutron capture cross section of 255,000 barns[7] has an abundance of 15.65% in the natural ore. Where numerical examples are given below, it will be assumed that the host metal is Pd and the catalyst is Gd-157.

The cold fusion process in the solid state can be described as a series of six subprocesses. These processes take place spontaneously once the host material, doped with the proper catalyst, is exposed to a controllable source of deuterons of the proper energy. The method by which the deuterons are introduced into the host material is not important, provided that the energy of a suitable fraction of those deuterons matches the energy of a neutron capture cross section maximum of the catalyst. In Gd, the cross section maximum occurs at room temperature with smaller cross section maxima occurring at the cross section resonant energies. The individual processes are as follows:

1) Freeing the Deuteron: Deuterons of the proper energy (or deuterium atoms, if thermal energies are sufficient to satisfy the energy requirement) are introduced into the host metal. The electrons associated with the ions or atoms are elevated into the conduction band of the host metal where they become free to move through the metal as do the other conduction band electrons. This also frees the deuterons to move through the metal.

2) Electron Shielding: The shielding provided by the orbital electrons and the conduction band electrons reduces the barrier potential to essentially zero at the radius for deuteron capture, thus reducing the energy requirement for nuclear penetration to the level of a few eV or less. Figure 4 shows how shielding can reduce the Coulombic force below the nuclear strong force and how the resonances (circled dots) are made available to assist in resonant capture.

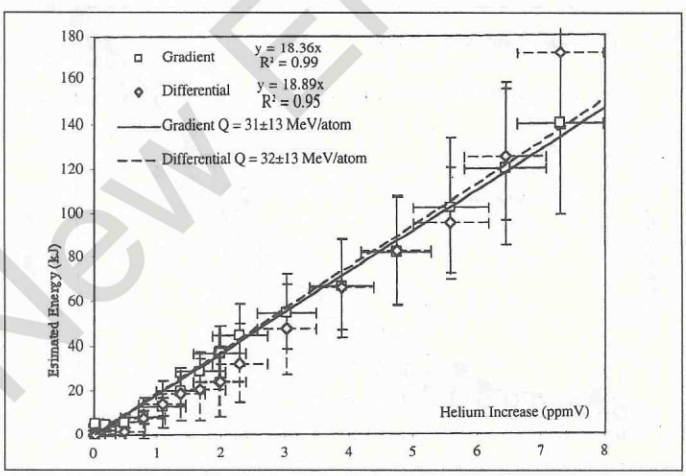

Figure 3. Estimated energy versus helium increase. (Courtesy of Mike McKubre *et al.*)

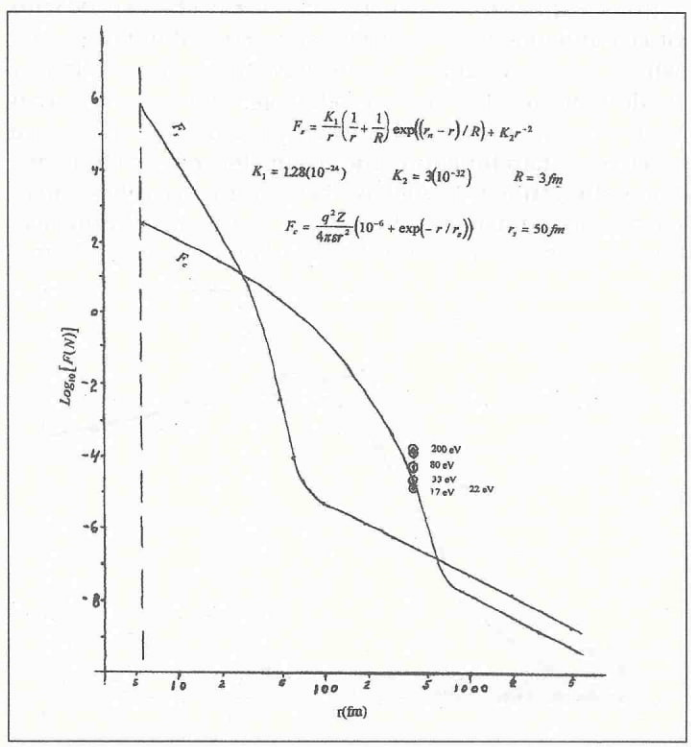

Figure 4. Nuclear forces in Pd/Gd-157.

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3) Deuteron Capture: By definition, capture occurs for any radius for which the (attractive) nuclear strong force exceeds the (repulsive) Coulombic force. It can take place in either of two processes, (a) by the accumulation of deuterons in an attractive "pocket" or "halo" (Figure 6) in the net force function or (b) by the approach to within the capture radius of a deuteron of the proper velocity or energy to match one of the cross section resonances shown in Figure 4.

4) A Second Capture: When a deuteron is captured by the catalyst, it resides for a time in an orbit of higher energy than the other nucleons, known as the "nuclear halo." This is known as a "composite nucleus." During the lifetime of the composite nucleus a second deuteron may be captured. Because of the tendency for nucleons to associate in pairs, the probability for capture of a second nucleon may exceed that for the capture of the first. It has been observed in certain light nuclei that the capture of a second nucleon may have a 100% probability.

5) Deuteron Fusion: When a second deuteron is captured by the same process in the same catalyst nucleus, the two deuterons will be occupying essentially the same energy state, and fusion takes place instantaneously. The fusion of the deuterons releases an energy of about 24 MeV in the production of an alpha particle, which is immediately ejected from the composite nucleus. The recoil of the catalyst nucleus absorbs half the momentum and a few percent of the energy. The ejected helium nucleus gives up its kinetic energy to the metal lattice through collisions with electrons.

6) Diffusion: Additional deuterons continue to arrive at the vicinity of the catalyst nucleus through the process known as solid state diffusion. The flow of particles through a solid is proportional to the particle density gradient and in the direction of decreasing density of the particles. This assures that deuterons will flow toward a region where they are being consumed by the fusion process.

The physics supporting these processes will now be discussed in greater detail.[7]

The Theory of Cold Fusion

1) Freeing the Deuteron

Because F&P and others initially overlooked the mechanism by which hydrogen isotopes in palladium are endowed with high mobility, they and others initially assumed that these mobile ions are confined to specific positions in the lattice of the host metal. Although they recognized that the hydrogen ions have high mobility in palladium, they confused the issue by stating that those ions occupy the octahedral interstitial positions in the lattice. Obviously the ions cannot be mobile if they are confined to certain fixed positions. Consequently they also overlooked the importance of the band theory of metals in understanding the processes of electron shielding in lowering the potential barrier to the approach of deuterons to a highly charged catalyst nucleus. A third consequence of overlooking the application of the band theory of metals is the failure to recognize the importance of ensuring that the catalyst atoms are sparsely distributed in the host metal.

In order for the fusion process to proceed, free deuterons must be produced. When dissimilar materials are placed in physical contact, thermodynamics requires that their Fermi energy levels come into equality. Applied to this case, this means that the electrons associated with the deuterium atoms must be at the same energy level as the conduction band electrons of the palladium. When atoms of hydrogen isotopes are absorbed into palladium, the electrons very quickly are stripped from the atoms and assimilated into the conduction band of the host metal. Because the hydrogen ions (hydrogen nuclei) now have no electrons to bind them to the host atoms, they are free to move through the host metal, as are the electrons. The high mobility of the deuterons arises mainly because the electron associated with each of them joins the conduction band electrons of the palladium.

If too high a concentration of catalyst atoms is used, those atoms will tend to precipitate out of solution and form microcrystalites. These, in turn, will form a band structure and have a Fermi energy of their own. Because the work functions of the catalyst and host materials are not equal, a potential barrier equal to the difference of the work functions will form at the interface of the two materials. In addition, since most metals readily form hydrides, deuterium will be captured in a chemical bond with the catalyst. The result will be a reduction of the mobility of the deuterons or their complete immobilization. On the other hand, if the catalyst is a metal and its concentration is sufficiently low that the catalyst atoms cannot mutually interact, then the valence electrons of the catalyst must join the conduction band of the host metal. This would indicate that, to achieve an average separation of at least ten host metal atoms in each direction for each catalyst atom, the concentration should be less than 0.1%.

It is of interest to calculate the average distance between palladium atoms (which would be the same as the average distance between deuterium ions at a loading ratio of 1:1) from the expression $r = (Mu/\delta) = 0.25$ nm where the density $\delta = 12.02$ gm/cm^3, the atomic weight $M = 106.42$, and the atomic mass unit $u = 1.66(10^{-24})$ gm. The deBroglie wave length of the electrons at 0.037 eV is 6.36 nm, which therefore extends over 25 palladium atoms. The electronic wave function extends essentially throughout the palladium, even into the vicinity of the palladium and catalyst nuclei. The amplitude of the electron wave function increases in the vicinity of positive charges, such as atomic nuclei and hydrogen ions.

It is also of interest to calculate the quantum mechanical wavelength of a deuteron at 160°C (an energy of 0.037 eV) from, $\lambda = h/p = 0.11$ nm which is about half the interatomic spacing of the palladium. The deuterons, being more massive, are more localized than the electrons. As the deuteron moves, the sea of conduction band electrons moves slightly to compensate for the change in the distribution of the positive charges. This change in average position of the electrons adds to the normal shielding of the deuteron by the inner electrons of the Gd nucleus. This means that the conduction band electrons are capable of shielding the deuterons as they move through the cloud of orbital electrons and approach the innermost orbits of the host or catalyst atoms. If they were not thus shielded, the orbits of the orbital electrons would be altered by the presence of the charged deuteron in their midst and the deuteron would not be mobile. A completely shielded deuteron is simply ignored by other charged particles.

2) Electron Shielding

Once the deuterons are freed, they must then be able to pen-

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etrate to the vicinity of the nucleus of the catalyst atoms closely enough to be captured, *i.e.* to the deuteron capture radius. The Coulombic potential barrier is greater than 30 MeV for an isolated fully ionized gadolinium atom. In the solid state, however, both the orbital electrons and the conduction band electrons are active in shielding the deuterons from the Coulombic forces, thereby reducing the amount of energy needed to penetrate the potential barrier.

The electrons in the solid material act in different ways to shield the deuterons from the intensely repulsive electrostatic force of the catalyst isotope nucleus. The orbital electrons in a solid shield the nucleus of an atom in essentially the same manner as when the atoms are isolated, that is, the effective charge of the nucleus in Equation 1 below is applied only once in Coulomb's Law. It is not squared. The orbital electrons which are interposed (on the average) between the deuteron and the catalyst nucleus reduce the effective charge of the nucleus in proportion to the fraction of the total number of electrons which are so interposed. The fraction of electrons so interposed increases in approximate proportionality to the radius of the electron orbit (treating the orbits as though they were circular), so the effective nuclear charge can be expressed as a linear function of the radial distance from the nucleus:

$$q Z_e = \frac{r_a - r}{r_a} Z q \qquad (1)$$

where r_a is the interatomic distance. The approximation is that the catalyst nucleus is unshielded at its surface but is totally shielded for radii greater than the interatomic radius.

The conduction band electrons, because they are mobile and have wave functions which extend over many times the interatomic distance, are much more effective in providing shielding. Large numbers of mobile electrons cluster around each positive ion, each lending a small fraction of their charge to form a negatively charged cloud around the ion. This shielding is effective in germanium, for example, to reduce the electric field intensity by a ratio of 16:1 through an increase (over a vacuum) of the dielectric constant by that factor. (Note that the effect of shielding can be expressed as either a decrease in the effective charge of a deuteron or an increase in the permittivity of the palladium.) Because the number of conduction band electrons in a metal is so large compared to that of the semiconductor germanium, the dielectric constant of a metal is essentially infinite. An increase in permittivity of a factor of a million would not be an unreasonable approximation. Only very feeble electric fields can exist in a metal like palladium. Ions embedded in a metal produce essentially no electric field; they are completely shielded externally. Inside an atom and especially near the nucleus, however, the shielding is not expected to be 100% effective.

The internal shielding by conduction band electrons can be treated as though it were a reduction of the charge of the deuteron, rather than a reduction of the charge of the catalyst nucleus. Each of the shielding effects is applied separately; that is, the effective charge in Equation 2 below is not squared when used in Coulomb's Law. This is an important consideration because the shielding provided by conduction electrons does not affect the orbital electrons. The conduction band electrons are attracted toward the interior of the catalyst atom by the presence of a deuterium ion or ions. Note that the presence of a D+ ion anywhere in the interior of an atom would require a compensating adjustment in the orbitals, unless that ion were completely shielded. For the ion to be mobile it must be surrounded by a cloud of electrons, each contributing a fraction of its charge to the cloud such that the total charge of the cloud is one electron. Also recall that the solitary electron of the deuterium atom has been stripped from the atom and is now in the conduction band of the palladium metal. The shielding effect can be approximated by a function of the distance from the catalyst nucleus, from no shielding at the nucleus to 100% shielding at the radius of the catalyst atom, and near 100% shielding at the Bohr radius. (The Bohr radius, given by the value 52,917/Z fm, is an approximation to the radius of the innermost electrons of an atom if the orbits were circular.) The last requirement is necessary to insure that the charge on the deuteron does not alter the energy levels of the orbital electrons. The simplest such function would be a step function, rising from zero at the surface of the catalyst nucleus to a constant fraction thereafter. A more reasonable function might be a power law function or an exponential function with a fixed minimum charge as suggested by Tipler *et al*:[8]

$$q_e = q(n + \exp(-r/R)) \qquad (2)$$

where q_e is the effective charge on the deuteron as reduced by conduction band electron shielding, R is a measure of the range of reduced shielding near the nucleus, and n is the smallest electronic fraction to which the effective charge will be reduced, which we will choose to be one microelectron. To achieve near 100% shielding at the Bohr radius, r_b, we must have $R << r_b$, so we will choose R equal to 50 fm, about 25 times the range of the nuclear strong force (which will be discussed in the next section). Obviously the correct values of these parameters and even the form of the function will have be determined, either experimentally or through more precise calculations. For the present, Equation 2 can serve to demonstrate the effects that conduction band shielding can produce. Equation 1 adds very little to the total shielding effect on the deuterons.

The effect of Equation 2 is that the Coulomb repulsion force decreases as the sum of a negative exponential and an inverse square. At several times the shielding range R, the exponential becomes negligible compared with the constant n, so the force function is converted to a simple inverse square function. The effect appears as a kink in the Coulombic force function, F_c, at about 500 fm as in Figure 4. The circled dots are a few of the prominent low-energy resonances.

3) Deuteron Capture

In order for a deuteron to be captured by a nucleus, the deuteron must approach the point where the combined nuclear strong force on the proton and the neutron exceeds the Coulombic force on the proton alone. At small radii the strong force overpowers the Coulombic force, and the deuteron accelerates toward the catalyst nucleus. At larger radii the Coulombic force exceeds the strong force in all isolated atoms. When a Gd-157 atom is isolated in a palladium lattice the form of the Coulombic force is altered by the electron shielding, as described above. The strong force may exceed the Coulombic at large radii. This allows deuterons to

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accumulate in the halo "pocket," facilitating both barrier penetration or fusion in the halo pocket itself.

The electron shielding has no effect on the nuclear strong force because the strong force does not interact with electrons. Outside the nucleus, the nuclear potential can be expressed by the Yukawa potential function:[8]

$$U(r) = \frac{K}{r} e^{-r/R} \quad . \tag{3}$$

The nuclear force per nucleon can then be derived by differentiating the potential function,

$$F = dU/dr = -\frac{K}{r}\left(\frac{1}{r} + \frac{1}{R}\right) e^{-r/R} \tag{4}$$

where the range parameter R determines how rapidly the force decreases with distance. The parameter K determines the magnitude of the force and has units of $N \cdot m^2$. The values of these two parameters can be determined from the neutron capture cross section and nuclear radius of the isotope, as follows:

At the surface of the nucleus, the strong force on a proton must exceed the Coulombic force on a proton in order to prevent protons from escaping from the nucleus. In a vacuum the Coulombic force on a proton in the vicinity of the nucleus with charge qZ, is given by the well- known expression

$$F_c = \frac{q^2 Z}{4\pi\varepsilon r^2} \tag{5}$$

where q is the electronic charge, Z is the atomic number of the nucleus, ε is the permittivity of a vacuum, and r is the radial distance to the center of charge. Because there is no electronic shielding at the surface of the nucleus, the values Z, q, and ε are the unshielded values. The radius of a nucleus is approximated by the expression $r = 1.2\ A^{1/3}$ where A is the atomic weight of the isotope. Using these values for gadolinium (Z = 64, and A = 157), we have $F_c = 352$ N for r = 6.47 fm in Equation 5. The nuclear strong force must be at least that great to keep a proton from escaping the nucleus. It is usually assumed that the strong force exceeds the Coulombic force by a factor of about 100. A commonly accepted value for the ratio of these forces is the reciprocal of the fine structure constant, 137. Substituting these values of F_s and r into Equation 4 yields an expression in R and K.

According to the standard theory, the strong force is mediated by virtual pions which have a mass of 141 MeV. Their lifetime as determined by the Uncertainty Principle is therefore $\Delta t = h/2\pi\Delta E = 5(10^{-24})$s. The distance a pion could travel in that time would be $c\Delta t = 1.4$ fm, so this would be the range of the strong force. Since the radius of the Gd157 nucleus is calculated to be 6.5 fm, it might be reasonable to use a larger range factor for the strong force in such a massive nucleus. For the calculations of Figures 4, 5, and 6 a range of 3 fm was used, but it turns out that this has little effect on the outcome. With the range factor now determined, one can complete the analysis of the Yukawa force. The result, shown in Figure 4, is that the Yukawa force alone does not account for the measured neutron cross section curves of gadolinium, especially at low energy.

The total cross sections for the gadolinium isotopes Gd-155 and Gd-157 have been measured[4] as a function of the neutron energy from 10 to 300 meV. At higher energies, in the region where resonances are present, up to about 3 KeV, there is no monoisotopic information shown. The maximum radius at which the low-energy neutrons interact with the nucleus of a single isotope at a particular energy is given by

$$r_c = (\sigma / \pi)^{1/2} \tag{6}$$

where σ is the neutron cross section. The neutron capture radius for Gd-157 at room temperature where the cross section is equal to 255,000 barns the capture radius is 2,849 fm. At this radius the nuclear force must be at least strong enough to deflect a passing thermal neutron into the nucleus of the isotope, that is

$$F = mv^2 / r_c = 2.82(10^{-9})N \ . \tag{7}$$

The velocity used is that at which the capture cross section was determined, v = 2,200 m/s, and m is the mass of the neutron. At the neutron capture radius the nuclear strong force must be at least great enough to actually capture a neutron. Because neutrons have no electrical charge, the centrifugal force is the only force opposing the strong force. It is therefore more convenient to calculate the strong force directly from the energy as

$$F_s = 2E / r \ . \tag{8}$$

When this is done for either Gd-155 or Gd-157, we find that the strong force in the low energy range is, within the plotting-error bars, an inverse square function of the radius, over four orders of magnitude.[9] This shows that the strong force, at least in certain isotopes, can be expressed as the sum of the Yukawa force and an inverse square force. This sum is plotted in Figure 4. The similarity of the shapes of the two curves, the strong force and the shielding function, should not be surprising as each is the sum of an exponential plus an inverse square.

The barrier potential is calculated by integrating the difference between the shielded Coulombic force and the strong force, from the atomic radius to the radius of the nucleus. In Figure 5, both the height and width of the potential barrier are reduced considerably by the electron shielding, making resonant capture more likely. Note also that there is a small negative energy region shown between 500-1000 fm. This, enlarged in Figure 6, is the "pocket" where deuterons can accumulate and fusion can occur.

4) A Second Capture

When a neutron or deuteron is captured by a more massive nucleus, it exists for a time in a condition of loose attachment to the other nucleus before being absorbed by the other nucleus and participating in whatever nuclear reactions are permitted. This combination is called a composite nucleus, and the energy states in which the neutron exists are called nuclear halo states. Because of the negative energy "pocket," positively charged ions (deuterons) can also accumulate in a region close to the catalyst nucleus. The possibility exists that a second deuteron can be captured within the life time of the composite nucleus formed by the capture

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of the first. The existence of permitted nuclear energy states, at large radial distances from the nucleus, can allow the composite nucleus to exist for times in the milliseconds. The potentiality of the neutron halo being useful to facilitate nuclear fusion was suggested by Takigawa and Sagawa as referenced by K. Riisager.[10]

Because protons and neutrons prefer to fill nuclear permitted energy states in pairs, as evidenced by the fact that elements that have the largest numbers of stable isotopes have even numbers of protons and the majority of those isotopes also have an even number of neutrons; the capture of two deuterons may have a similar probability as, or even greater than, the capture of only one. Austin *et al.*[11] have reported observing this effect with neutrons in lithium, which has two occupied neutron halo states at a distance of twice the radius of the nuclear core. If one of the two halo neutrons is removed, the other is immediately ejected. The Li-9 nucleus actually "prefers," with 100% probability, to capture two neutrons rather than just one. The probability of a two-deuteron capture would be expected to be enlarged by the fact that deuterons are bosons, and can therefore exist in identical energy states.

Experimental evidence for the capture of two deuterons simultaneously lies in the observed nuclear activity which is initiated by low-energy processes involving the use of deuterated palladium.[1] Direct d-d fusion is ruled out because of the 0.48 MeV Coulomb barrier. The capture of a single deuteron by a catalyst of any kind, including palladium itself, would not result in the production of He-4 or H-3. The evidence presented by Claytor *et al.*[12] for the production of tritium through the bombardment of deuterated palladium with 1.5 - 2.5 KeV deuterons is one such case. Although nuclear transmutation is occurring, direct d-d fusion is again ruled out. The energy they were using was far too small to overcome the repulsive forces. Clearly the nuclear strong force and electron shielding were involved, but even these, acting on deuterons alone, would not compensate for the small d-d reaction cross section at low energies. An unknown catalyst, X, must have been present to participate in a two-step process involving the simultaneous capture of two deuterons, as:

$$(X + d) + d \rightarrow (Xd) + d \rightarrow (X(dd)^*) \rightarrow X + H\text{-}3 + p + Q \quad (9)$$

where the asterisk indicates that the composite nucleus in now in an excited state, caused by the energy released by the fusion of the two deuterons.

When this necessity first became apparent, rhodium was identified as the most likely catalyst,[13] as its isotope Rh-105 has the required high neutron capture cross section (5,000 b) and half life (35.4 hours) to account for most of the observations of F&P and M. Miles.[14] In addition to rhodium being a natural minor impurity in palladium, it also has the capability of being naturally produced in small quantities from Pd-102, through the capture of background neutrons and subsequent beta-decay of Pd-103. Unfortunately, the properties of rhodium that explain the observed production of heat and helium are also associated with the unpredictability and randomness of neutron capture and radioactive decay, the properties that cause the unreliability and lack of reproducibility. Although it has an isotope that can serve as a nuclear catalyst in the production of helium and heat at low energy levels, the fact that Rh-105 does not occur naturally means that this isotope must be produced in situ by a process including two to four nuclear reactions which, although well-known, make the overall process inherently slow and unreliable. This is true whether the apparatus used in the process is an electrolysis cell of the type used by F&P, or a pressurized gas chamber of the type used by Leslie Case[3] in his experiments.

In the interaction of a deuteron with a heavier nucleus, an intermediate or composite nucleus is sometimes formed which lasts "a long time," as much as nine milliseconds in the case of neutrons in Li-11 in Austin's experiment. The composite nucleus consists of a deuteron loosely bound to the heavier nucleus, and occupying the nuclear halo of the nucleus. Considerably less time than 9 ms would be adequate to allow many additional deuterons to reach the vicinity of the capture radius. At 1,900 m/s, the time required for a deuteron to cross the distance from the outer reaches of a gadolinium atom to the nucleus (about 0.25 nm) is only 0.13 ps. Since the measured lifetime for some composite nuclei is so much longer, there would be adequate time for a second deuteron capture. At a near 1:1 loading ratio there would be several deuterons loitering about any given catalyst atom at any one time.

The rate at which deuterons will be delivered to the vicinity of the catalyst nucleus will depend on the rate at which

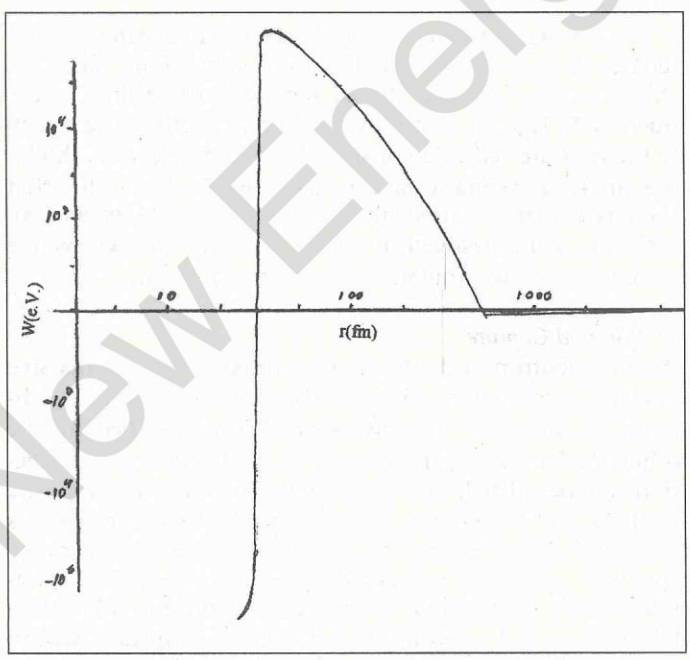

Figure 5. Barrier potentials in deuterated Pd/Gd-157.

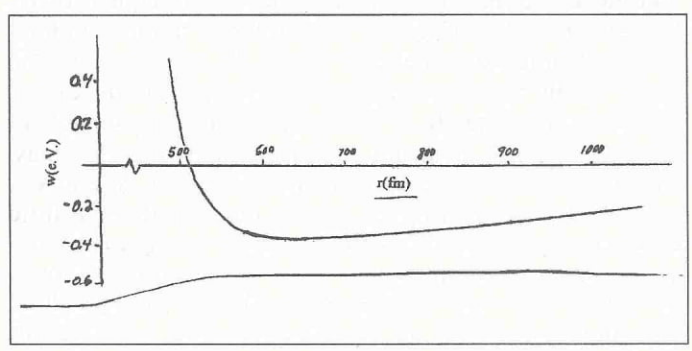

Figure 6. Deuteron energies in deuterated Pd/Gd-157.

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deuterium is absorbed by the palladium, not on the lifetime of the composite nucleus. Some of these will accumulate in the halo pocket and once two deuterons are within the nuclear halo (Gd + d + d) where they are separated by a few hundred fm or less and are in the same or nearly the same energy state, they will combine almost instantaneously, in not less than 10^{-22}s according to the Heisenberg Uncertainty Principle, $\Delta t = h/2\pi\Delta E$, where the energy uncertainty is the energy released in the reaction, about 24 MeV. Because deuterons are (spin 1) bosons there is no limit to the number which can occupy the same energy state. Because of the high neutron capture cross section of Gd-157 and the high mobility of deuterons in palladium, this process will begin as soon as deuterons of the proper energy are present in the Pd which has been doped with Gd.

5) Deuteron Fusion

The fusion of two deuterons in the nuclear halo of a catalyst nucleus takes place by a different process than that in the F&P process. The process (10c) that does take place is well known, but in direct d-d fusion it proceeds at about one one-millionth of the rate of the two other processes. This fusion process is not even mentioned in the 1989 F&P paper, nor did they mention having searched for He-4. Therefore its discussion here is extremely important.

Once two deuterons have combined, there are three modes of decay or "exit channels" for the composite nucleus (Gd + He-4) formed in the halo region of one of the catalyst nuclei after the capture of two deuterium atoms. They are the same as the ones that are available when deuterium atoms are bombarded with energetic deuterium atoms, namely:

a) d + d + KE → He-4* → H-3 + p + (KE + 4.03 MeV)

b) d + d + KE → He-4* → He-3 + n + (KE + 3.27 MeV) (10)

and c) d + d + KE → He-4* → He-4 + (KE + 23.85 MeV)

or d) d + d + KE → He-4* → d + d + KE

that is, the pair of either captured or collided deuterons can transmute to reaction products in any of those ways. The energy released in the process, including the kinetic energy of the incident nuclei, can appear as kinetic energy of the particles shown, or be shared with the catalyst nucleus. Secondary reactions may generate gamma rays. Which of these is the preferred exit channel is determined largely by the amount of energy released and the conservation laws regarding energy, momentum, baryon number, lepton number, and spin. In each case baryon number, lepton number, and spin are satisfied by the reaction particles listed. The released energy must be divided among the reaction products in such a way that the energy and momentum conservation laws are satisfied. This much of the process of the fusion of two deuterium ions is the same whether they fuse because they collided with high kinetic energy in a Tokamak or an H-bomb, called "hot" fusion, or whether they fuse because they are captured in the halo of the nucleus of an atom which has a high neutron capture cross section, in the process known as "cold" fusion. What happens next is much different in the two cases. Let us begin with the more familiar "hot" fusion.

Consider the first two exit channels, where there are two particles emitted in each case. In each case the two particles simply divide the energy in inverse proportion to their masses, $E_1/E_2 = m_2/m_1$. By flying off in opposite directions, the particles then satisfy the momentum conservation, $-m_1v_1 = m_2v_2$. Since the energy evolved is about the same in the first two cases, they occur with about equal probability. Gamma rays of less than a few MeV are produced by secondary reactions. In the third case, involving the production of He-4, there is only one particle produced, an α particle, so the only way to satisfy the two conservation laws in vacuum is that most of the energy released, about 23.8 MeV, must be carried off by gamma rays. However, although gamma rays are seen in the collision reaction, the third exit channel is scarcely used. The reason is that in the collision experiment the kinetic energy of the colliding deuterons must be accounted for. Thus the total energy that the α particle must dispose of is the 23.8 MeV of binding energy plus the kinetic energy of the deuterons. This sum exceeds the binding energy of the He-4 nucleus, so the α particle immediately decays back into two deuterons as in 10d; or in other words, the fusion reaction 10c is seldom observed in the collision experiment. Because the energy exchange in either a or b is less than that in c or d, the Uncertainty Principle permits reaction d to occur in less time than the minimum time available for either a or b. This means that reaction d is actually the preferred exit channel, but it is not seen because the end products are identical with the initial particles.

In the solid state, the selection of the exit channels proceeds in a different manner, especially in the third case involving the production of He-4. Because the fusing particles have negligible (only meV to KeV) kinetic energy compared to the binding energy of the He-4 nucleus, the α particle is formed within the nuclear halo of the catalyst nucleus with little or no excess energy beyond the binding energy; and now there is another particle, the catalyst nucleus, to share in the energy-momentum equation. The α particle and the catalyst (assumed to be Gd-157) nucleus share the energy in inverse proportion to their masses,

$$\frac{E_{Gd}}{E_{He}} = \frac{m_{He}}{m_{Gd}} = \frac{4}{157} = 0.0255.$$

Thus the Gd-157 recoils with 2.55% of the total energy of 23.8 MeV, or 0.61 MeV which leaves the α with 23.2 MeV which is less than its binding energy. It is not destroyed and a gamma ray is not needed to balance the conservation laws. The α particle can carry off its energy in kinetic form and give it up to the lattice through repeated interactions with electrons (typically within a few hundred microns). Because c and d are more energetic reactions than a or b, c becomes the favored exit channel. Since reactions a and b go almost unused, there are essentially no neutrons, no protons, no tritium, and only a few gamma rays produced by the particles that escape from the host material before dissipating their energy in the metal. The gamma rays are produced by collisions of the alpha particles that escape from the metal with the atoms of the electrolyte or other surrounding material.

In addition to the few neutrons, protons, and tritons produced by the greatly suppressed use of the first two exit channels (10a and 10b), other reaction products will be produced in small quantities through high energy collisions (up to 24 MeV) of the alpha particles with the nuclei of the palladium and those of unwanted impurity atoms in the Pd.

The problem of how the alpha particle can transfer its

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energy to the host metal lattice needs to be examined. In direct d-d fusion of the F&P hypothesis, the He-4* is formed near the interstitial octahedral sites, where they assumed that the deuterons reside. In that location the He nucleus would be able to interact with only one electron which would have to absorb the majority of the 24 MeV because it is so much lighter than the alpha particle. The production of such highly relativistic electrons has not been observed.

In the solid state the He is formed in the immediate vicinity of a massive nucleus (Gd-157) to which it can transfer enough of its energy (0.61 MeV) to reduce the excitation energy to a value less than the binding energy (23.8 MeV). Once the excitation energy of the He nucleus is reduced to below the binding energy, there is no way that it can decompose. The remainder of the excitation energy is converted to kinetic energy of the alpha particle, which can then transfer energy to the lattice through ionizing collisions with conduction band and orbital electrons.

The deuterons tend to cluster in the negative energy "pocket" at a few hundred femtometers, so one might question how the necessary amount of energy could be transferred from the excited alpha particle to the catalyst nucleus. The speed-of-light limit sets the minimum time, $t = 600$ fm/c $= 2(10^{-21})$sec. for the transfer by an electromagnetic process. The Uncertainty Principle requires that the minimum time for the transfer is 10^{-21} sec. to exchange 0.61 MeV of energy. (Note that this process is the inverse of the Mössbauer effect, wherein cooling of the lattice immobilizes the heavier nucleus so that there is no recoil to absorb part of the energy.)

6) Diffusion

The deuteron flux density must be high enough that two deuterons may be captured during the lifetime of composite nucleus.

The process by which the deuterons (and electrons) move through the metal lattice consists of a series of essentially straight-line paths between collisions with "scattering centers" which consist of lattice defects such as dislocations, grain boundaries, interstitial atoms or impurity atoms or other charged particles, and phonons. The velocity of the particles between collisions is determined by the energy $v = \sqrt{2E/m}$, where m is the mass of the particle. If the energy of the particles is determined by the temperature, then the energy distribution is determined by the Maxwell distribution function. The average energy of a Maxwell distribution function is 3kT/2, and the energy at the peak energy density is kT/2, (the energy at the midpoint of those two, just kT, is often used), where k is the Boltzmann constant and T is the absolute temperature. The overall process is ordinary solid state diffusion; the behavior is like that of a gas diffusing through the atmosphere. The diffusion process can be represented by Fick's first law in one dimension, expressed as

$$f = -D\frac{\partial N}{\partial x}$$

where f is the number of particles per second per square centimeter, known as the particle flux. The partial differential is the gradient of the particle volume density with respect to distance, and D is a parameter known as the diffusion coefficient, equal to 10^{-7} cm^2/sec. The equation states that the particle flux is proportional to the particle density gradient and will be in the direction in which the particle density decreases. Thus, the laws of diffusion demand that the diffusing particles must move from an area of higher density to one where their density is lower. If there is a point in the material at which particles are being consumed, then the other particles of the same species are constrained to diffuse toward that point. The problem we are faced with is that with the high loading factors that are used, the concentration of deuterium in the palladium is approximately uniform. Since the concentration gradient is essentially zero, the normal laws of diffusion do not apply.

We can make an estimate of performance by considering a cathode consisting of a thin sheet of palladium of thickness t, with gadolinium atoms dispersed uniformly at a concentration c_v, throughout the cathode. The inverse cube of the average interatomic spacing is the number of palladium atoms per cubic centimeter, so the concentration of Gd atoms $c_v = d/r^3$, where d is the doping ratio. The surface concentration of catalyst atoms is $c_s = tc_v$ (At/cm^2). The cathode current density is J Amperes per square centimeter so the surface flux of deuterium ions is J/q ions/cm^2/sec. The ionic capture probability is then is σc_s. The power generated under these assumptions is

$$P = \sigma c_s WJ \qquad (12)$$

where W is the energy released per reaction in electron volts. For a gadolinium concentration of 1ppm, a cathode thickness of 10 microns, and an energy release of 24 MeV, the power output is 400 Watts/Ampere/cm^2. Note that the above analysis assumes that the deuterium ions pass only once through the palladium layer, escaping through its far side. If the deuterons are retained in the palladium, the power output will be increased, presumably by a large factor.

Because of the very large power output capability, it is important that the quantity of loaded deuterium be under the complete control of the applied current. There should be no volume of palladium which has no catalyst atoms but which contains stored deuterium. This would constitute a potentially dangerous source of uncontrolled energy.

Conclusions

The net force on a deuteron is given by the difference of the shielded Coulomb force minus twice the nuclear strong force. The factor of two enters because there are two nucleons in a deuteron, only one of which carries an electric charge. Figure 4 shows an example of the radial dependence of the magnitude of the two forces in Gd-157 under the assumptions and approximations of the model. The barrier potential is obtained by integrating the net force over the distance from the atomic radius to the radius of the catalyst nucleus. Because the integrand is rather complex, a closed form for the barrier potential was not obtained. A numerical integration was performed to obtain the barrier potential.

As shown in the text, the strong force in both Gd-155 and Gd-157 extended "tails" which approximate inverse square functions. While it is these tails that give these isotopes their enhanced neutron capture cross sections, it is the fact that the tail decreases only as an inverse square of the radius that make these isotopes such attractive candidates for nuclear catalysis. Analysis of a few other isotopes

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has shown that, while they also display extended power-law tails, the power tends to be larger. For the present it appears that the most promising, and safest, experiments would involve a thin palladium cathode with a uniform concentration of gadolinium of 1 ppm or less. If the composition is supported by a metallic substrate, the metal should be a good conductor of heat, but should *not* be capable of storing quantities of deuterium.

Although the model presently includes several assumptions and approximations, most are reasonable. It will be possible to improve the accuracy of assumptions such as the shape of the electronic shielding function, once the guidance of experimental work is available. Meanwhile the model demonstrates the feasibility of the cold fusion process, and can be used to guide the further theoretical work. The model as developed, step by step, refutes the objections of Dr. Huizenga[5] at every step.

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About the Author

Mr. Josephs became interested in atomic and nuclear physics with the announcement of the destruction of Hiroshima. He developed his interest in relativity during his four-year term of service in the Air Force. He was educated at Midwestern University (Texas); the University of Minnesota; and in 1959 received the Master of Electrical Engineering degree from New York University. While at Minnesota, Mr. Josephs worked three years as an engineer on the linear proton accelerator in the Physics department. He was employed by Bell Telephone Laboratories in the Solid State Device Development Department for three years, while attending NYU. He worked for ten years for Honeywell, Inc. in Minneapolis in a variety of positions, mostly at the Solid State Electronics Center, developing integrated circuits and IC production processes. He spent the last twenty-one years of his working career as a Professor of Electronics at Alexandria Technical College (Minnesota). Mr. Josephs has published more than two dozen technical papers and has several U.S. patents. He has served on technical and political committees and organized the first Solid State Sensors Symposium. He was a senior member of the Institute of Electrical and Electronic Engineers (IEEE) and served as guest editor of the IEEE "Transactions on Electron Devices." Mr. Josephs is a licensed private pilot and extra class amateur radio operator. He retired from academia in 1990 and has engaged in cold fusion research since 1989.

*HCR 64, Box 708, Guadalupita, New Mexico 87722

Editor's Note: *Infinite Energy* does not employ a traditional formal review process for its technical manuscripts. Manuscripts are reviewed internally, of course, and, less frequently, externally. We believe that in an era when much of the so-called "rock-solid" foundational paradigms of science are being called into question on a broad front—for very good reason—there is really no satisfactory formal "peer review" system per se that we would wish to employ. We believe that it is to the advantage of readers to judge whether the papers they read in *Infinite Energy* are promising or marginal, or have particular unresolved errors in them. On occasion, we believe that it is useful to present what one or more reviewers have said about some published manuscript—side-by-side with the article. So, we are happy in this case to be able to present Dr. Scott Chubb's comments about Dr. Josephs' article and the author's reply. —*Eugene F. Mallove*

Commentary on Josephs' Cold Fusion Theory

by Dr. Scott Chubb

H.C. Josephs' paper includes a potentially important idea: the use of gadolinium as a catalyst in "cold fusion" experiments. The paper also provides a "picture" for understanding how conventional solid state physics effects can allow for "cold fusion" to occur. The problems associated with the

paper are two-fold: 1) The author has not appropriately referenced theoretical work in the more general (LENR) field, 2) There are technical problems, associated with the particular model that has been adopted, that would be called into question, by mainstream condensed matter physicists.

In fact, a simple solution to both problems could involve using suitable references, with regard to the motivating arguments. In particular, the author, independently, appears to have identified an intuitive picture of how nuclear reactions might occur in solids, based on certain assumptions about the effective ionicity of potentially interacting deuterium atoms, with a Pd (or other) host material. His picture of this, which is consistent with the ion band state picture suggested by Chubb and Chubb (see www.lenr-canr.org), is based on the electronic structure of the host materials (in particular that the 4d10, 5s0, configuration associated with Pd would be conducive to a counterintuitive form of deuterium atom bonding to the Pd lattice). This picture, which includes the idea that the deuterium atoms (D's) behave like deuteron (d) ions, is considerably more sophisticated than ideas that have been presented by most theorists who have been involved either in supporting or discrediting the idea that a theoretical basis for cold fusion might exist. He also has suggested a novel, alternative scenario, involving the use of Gadolinium, as a way of catalyzing potential reactions.

The source of "errors" with the paper involve a common problem with this field: the use of a particular model, involving sets of details that can be questioned. In the present paper, serious problems exist because a number of these assumptions have such limited applicability that they will undoubtedly be questioned. The key difficulty, in this respect, involves questions related to time-scale and interaction. In particular, the model of electromagnetic interaction, between deuterons (d's) with each other, and with the lattice, involves a particular construction, associated with a static picture, based on the standard Coulomb interaction, using particular assumptions about the limit in which the permittivity ε becomes large (so that the Coulomb Force between charges q_1 and q_2, located at r_1 and r_2 $= \frac{q_1 q_2}{\varepsilon |r_1 - r_2|}$, becomes small), is the dominant relevant force in the nuclear reaction. In fact, although this assumption includes a key point (that potentially the Coulomb barrier not impede interaction in a solid), the underlying construction has a potentially damning limitation: in metals, the force between charges involves both the behavior of the static charges, and the currents that would result from a redistribution of the charges. The key point is that the model of a static interaction has limitations; when currents are present, the permittivity ε does not adequately describe the force because Eddy currents occur, and (as a consequence), this quantity acquires an imaginary component (which is proportional to the conductivity).

An appropriate description about the relationship between the time of response and the behavior of currents is an important way to deal with this kind of criticism. Both during ICCF1, and in his book (*QED Coherence in Matter*, World Scientific Publishing Co., Singapore; ISBN 9810222491, 1995, Chapter 8, pp. 153-178), Giuliano Preparata has attempted to deal with this problem, in general terms. Talbot Chubb and I have pointed out that an entirely different situation, that is peculiar to hydrogen/deuterium-transition metal environments, can circumvent both the permittivity and current problem, through a coherent effect, associated with ion band stand occupation. (In one way or another, all of our papers, beginning in 1991 until the present time have dealt with this question; details about our work can be found at www.lenr-canr.org.) My recommendation is that if the author wishes to discuss the static limit, he refer to our work, in an appropriate way. In particular, we have suggested that in particular limits, the kind of itinerant picture (in which each d-nucleus appears to be freely able to move about the lattice) that the author suggests fits well within the context of our ion band state model. An important distinction exists, however: because the author has focused on a particular model involving occupation of this kind of state in the presence of a catalyst, his model fails to include potentially important effects associated with the occupation of this kind of state, and how this might be triggered through particular loading procedures.

A potentially more important, but subtler problem is associated with the author's comments about the $d+d \rightarrow {}^4He+\gamma$ reaction, and the role of "excitation"/"de-excitation" through (for example) interaction with the catalyst, and the possibility for γ ray suppression. In fact, although the $d+d \rightarrow {}^4He+\gamma$ reaction rarely occurs in fusion (and is not widely cited in fusion literature, as a consequence), its underlying dynamics and origin is well understood from detailed studies of the reverse (photo-dissociation of ${}^4He$ into d's) reaction, ${}^4He+\gamma \rightarrow d+d$, which includes a detailed comparison between theory and experiment [see for example, D.R. Thompson, *Nuclear Physics A*, Vol. A1, 54, No. 2, 442-8 (1970), and references, included there].

The key point is the role of electromagnetic interaction in this reaction not only is dominant and required to be included even far from the reaction, but because of this fact, important features (involving spin and particle exchange statistics) come into play. For this reason, selection rules associated with it are not at all related to those that occur in the dominant ($d+d \rightarrow {}^3He+n$, $d+d \rightarrow {}^3H+p$) fusion reactions. The $d+d \rightarrow {}^4He+\gamma$ reaction involves a quadrupolar, ${}^2D_0 \rightarrow {}^0S_0$ transition (in which the two d's occupy an orbital angular momentum=2, spin=0 D-state, similar to two electrons in a D-state molecule, that decays to a singlet, angular momentum=0, spin=0 S-state). The reason the reaction does not occur in conventional fusion is because the two d's are required to behave as bosons at locations, far from the location of the reaction.

The problem with the existing wording is three-fold: 1) The $d+d \rightarrow {}^4He+\gamma$ reaction involves important coupling to the electromagnetic field that is time- and spatially- dependent in a manner that is not at all related to the remaining transitions; 2) As a consequence, there is every reason to believe that a gamma ray could be released, even in the presence of the reduction by .61 MeV of the potential reactants. Alternatively, the point is that conservation of lepton number, energy, and momentum, by themselves, are not sufficient to explain either why the transition does not occur frequently in conventional fusion or to justify why it does or doesn't occur in solids. Effects associated with boson exchange play an important role in this respect.

My recommendation, with regard to addressing these

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criticisms would be to point out that 1) The d+d→^{4}He+γ ray reaction involves important coupling to the electromagnetic field in a way that could significantly impede γ-ray release (through large-distance coupling to the solid), which can be envisioned as occurring through a gradual de-excitation process (in which ^{4}He* gradually couples to the lattice); 2) The problem of overcoming the Coulomb barrier can occur through electromagnetic interaction with the solid. Details about this are still being debated. But two prominent ideas are that this can occur either through dynamic coherent coupling (refer to Preparata), or through a static, coherent form of coupling (refer to Chubb and Chubb), that would appear to be important at low temperature. ❐❐❐

Response to Review and Comments by Dr. Scott Chubb

Dr. Chubb has offered several welcome comments and suggestions for improving and expanding the theory proposed in the referenced paper. Suggestions, additions, and modifications from any and all sources are welcomed. Dr. Chubb's criticism regarding the lack of references to prior work is acknowledged with the admission that this author has not perused all of the thousand plus publications in the cold fusion field.

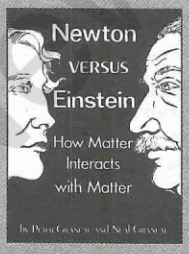
The comments regarding the emission of gamma rays are well taken. Certainly there is a probability that the excited helium nucleus (He-4*) can release its total excitation energy (KE + 23.85 MeV) through the release of a gamma ray, or gamma rays, before it can transfer the required kinetic energy and momentum to the catalyst nucleus by way of electromagnetic processes. However, once the required energy and momentum transfer has occurred, the energy is in kinetic form, rather than nuclear excitation energy. The 23.2 MeV of the alpha particle is transferred to the lattice by collisions with electrons. Because He-4 has no excited states at lower energy, there is no process by which it can give up excitation energy directly to the lattice, little by little.

In regard to the effect of shielding on the permittivity, in the model the d-d interaction occurs within a few hundred femtometers of the nucleus where the density of orbital electrons is small and the total charge of the electrons that are doing the shielding is still only one or two electrons, since it is only one or two deuterons that are to be shielded. This maintains the net charge due to the mobile deuterons and conduction band electrons in the vicinity of the nucleus at the value zero. The potential field in that region is established by the charge of the catalyst nucleus, Ze. Rather than attempt to assign different values of permittivity to different charges or regions of space, it is easier to maintain the permittivity at the vacuum level and vary the changes according to the amount of shielding. The effect of reducing the charge is identical to the effect of increasing the permittivity.

In this author's opinion, the main weakness of this model is the need for two arbitrary constants, n and R, in the shielding function. A potential partial solution to this problem has surfaced in a recently-acquired text [Jean-Noel Chazalviel, *Coulomb Screening by Mobile Charges*, Birkhauser, Boston, 1999] which develops the shielding charge density for an isolated charge as

$$\rho = \frac{-Q}{4\pi r \lambda_D^2} \exp(-r/\lambda_D)$$

where Q is the shielded charge (a deuteron), $\lambda_D = [\varepsilon kT/ne^2]^{1/2}$ is the Debye length, and n is the electron density in the host metal, 2 (10^{29} m^{-3}). Because we are considering the shielding of deuterons in the vicinity of a gadolinium nucleus, the squared factor in the denominator of the expression for the Debye length should be Ze. Using this modified Debye length in Tipler's expression for the shielding function we have a shielding range of 42 fm, in good agreement with the 50 fm value used. —*H.C. Josephs*



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Force on an Asymmetric Capacitor

Thomas B. Bahder* and Chris Fazi*

Abstract

When a high voltage (~30 kV) is applied to a capacitor whose electrodes have different physical dimensions, the capacitor experiences a net force toward the smaller electrode (Biefeld-Brown effect). We have verified this effect by building four capacitors of different shapes. The effect may have applications to vehicle propulsion and dielectric pumps. We review the history of this effect briefly through the history of patents by Thomas Townsend Brown. At present, the physical basis for the Biefeld-Brown effect is not understood. The order of magnitude of the net force on the asymmetric capacitor is estimated assuming two different mechanisms of charge conduction between its electrodes: ballistic ionic wind and ionic drift. The calculations indicate that ionic wind is at least three orders of magnitude too small to explain the magnitude of the observed force on the capacitor. The ionic drift transport assumption leads to the correct order of magnitude for the force, however, it is difficult to see how ionic drift enters into the theory. Finally, we present a detailed thermodynamic treatment of the net force on an asymmetric capacitor. In the future, to understand this effect, a detailed theoretical model must be constructed that takes into account plasma effects: ionization of gas (or air) in the high electric field region, charge transport, and resulting dynamic forces on the electrodes. The next series of experiments should determine whether the effect occurs in vacuum, and a careful study should be carried out to determine the dependence of the observed force on gas pressure, gas species, and applied voltage.

1. Introduction

Recently, there is a great deal of interest in the Biefeld-Brown effect, *i.e.* when a high voltage (~30 kV) is applied to the electrodes of an asymmetric capacitor, a net force is observed on the capacitor. By asymmetric, we mean that the physical dimensions of the two electrodes are different, *i.e.* one electrode is large and the other small. According to the classical Biefeld-Brown effect (see Brown's original 1960, 1962, and 1965 patents cited in Appendix A, and a partial reproduction in Section 2), the largest force on the capacitor is in a direction from the negative (larger) electrode toward the positive (smaller) electrode. Today, there are numerous demonstrations of this effect on the Internet in devices called "lifters," which show that the force on the capacitor exceeds its weight.[1] In fact, these experiments indicate that there is a force on the capacitor independent of polarity of applied voltage. In the future, the Biefeld-Brown effect may have application to aircraft or vehicle propulsion, with no moving parts. At the present time, there is no accepted detailed theory to explain this effect, and hence the potential of this effect for applications is unknown. The authors are aware of only two reports[2] and theoretical papers that address such issues.[3,4]

In Section 2, we describe the history of the Biefeld-Brown effect. The effect of a net force on an asymmetric capacitor is so surprising that we carried out preliminary simple experiments at the U.S. Army Research Laboratory (ARL) to verify that the effect is real. The results of these experiments are described in Section 3. Section 4 contains estimates of the force on the capacitor for the case of ballistic ionic wind and drift of carriers across the capacitor's gap between electrodes. In Section 5, we present a detailed thermodynamic treatment of the force on an asymmetric capacitor, assuming that a non-linear dielectric fluid fills the region between capacitor electrodes. Section 6 is a summary and recommendation for future experimental and theoretical work.

2. Biefeld-Brown Effect

During the 1920s, Thomas Townsend Brown was experimenting with an X-ray tube known as a "Coolidge tube," which was invented in 1913 by the American physical chemist William D. Coolidge. Brown found that the Coolidge tube exhibited a net force (a thrust) when it was turned on. He believed that he had discovered a new principle of electromagnetism and gravity. Brown applied for a British patent on April 15, 1927, which was issued on November 15, 1928 as Patent No. 300,311, entitled, "Method of Producing Force or Motion." The patent and its figures clearly describe Brown's early work on forces on asymmetric capacitors, although the electromagnetic concepts are mixed with gravitational concepts (Figure 1).

The discovery of the Biefeld-Brown effect is generally credited to Thomas Townsend Brown. However, it is also named in honor of Brown's mentor, Dr. Paul Alfred Biefeld, a professor of physics and astronomy at Denison University in Granville, Ohio, where Brown was a laboratory assistant in electronics in the Department of Physics. During the 1920s, Biefeld and Brown together experimented on capacitors.

In order to find a technical description of the Biefeld-Brown effect, we performed a search of the standard article literature and found no references to this effect. It is prudent to ask whether this effect is real or rumor. On the other hand, the Internet is full of discussions and references to this effect, including citations of patents issued,[1] see also Appendix A. In fact, patents seem to be the only official publications that describe this effect.

On July 3, 1957, Brown filed another patent entitled "Electrokinetic Apparatus," and was issued U.S. Patent No. 2,949,550 on August 16, 1960. The effect in this patent is described more lucidly than his previous patent No.

> This invention relates to a method of controlling gravitation and for deriving power therefrom, and to a method of producing linear force or motion. The method is fundamentally electrical.

Figure 1. Excerpt from Thomas Townsend Brown's British Patent No. 300,311, entitled "Method of Producing Force or Motion," issued on November 15, 1928.

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This invention was disclosed and described in my application Serial No. 293,465, filed June 13, 1952, which application has become abandoned. However, reference may be made to this application for the purpose of completing the disclosure set forth below.

The invention utilizes a heretofore unknown electrokinetic phenomenon which I have discovered; namely, that when a pair of electrodes of appropriate form are held in a certain fixed spaced relation to each other and immersed in a dielectric medium and then oppositely charged to an appropriate degree, a force is produced tending to move the pair of electrodes through the medium. The invention is concerned primarily with certain apparatus for utilizing such phenomenon in various manners to be described.

Figure 2. Excerpt from Thomas Townsend Brown's U.S. Patent No. 2,949,550, entitled "Electrokinetic Apparatus," issued on August 16, 1960.

300,311, of November 15, 1928. In this 1960 patent, entitled "Electrokinetic Apparatus," Brown makes no reference to gravitational effects (Figure 2).

The claims, as well as the drawings in this patent, clearly show that Brown had conceived that the force developed on an asymmetrical capacitor could be used for vehicle propulsion. His drawings in this patent are strikingly similar to some of the capacitor designs on the Internet today. In this 1960 patent, Brown gives the clearest explanation of the physics of the Biefeld-Brown effect. Brown makes several important statements, including:

- the greatest force on the capacitor is created when the small electrode is positive
- the effect occurs in a dielectric medium (air)
- the effect can be used for vehicle propulsion or as a pump of dielectric fluid
- Brown's understanding of the effect, in terms of ionic motion
- the detailed physics of the effect is not understood

In Figure 3 we reproduce Brown's partial text explaining the effect and in Figure 4 his first two figures.

Soon after Brown's 1957 filing for the patent previously mentioned, on May 12, 1958, A.H. Bahnson, Jr. filed for an improved patent entitled "Electrical Thrust Producing Device," which was granted U.S. Patent No. 2,958,790 on November 1, 1960.

On July 3, 1957, Brown filed another patent (granted on January 23, 1962, as U.S. Patent No. 3,018,394) for an "Electrokinetic Transducer." This patent deals with the inverse effect, *i.e.* when a dielectric medium is made to move between high voltage electrodes, there is a change in the voltage on the

2,949,550

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I have discovered that when apparatus of the character just described is immersed in a dielectric medium, as for example, the ordinary air of the atmosphere, there is produced a force tending to move the entire assembly through the medium, and this force is applied in such direction as to tend to move the body 20 toward the leading electrode 21. This force produces relative motion between the apparatus and the surrounding fluid dielectric. Thus, if the apparatus is held in a fixed position, the dielectric medium is caused to move past the apparatus and to this extent the apparatus may be considered as analogous to a pump or fan. Conversely, if the apparatus is free to move, the relative motion between the medium and the apparatus results in a forward motion of the apparatus, and it is thus seen that the apparatus is a self-propulsive device.

While the phenomenon just described has been observed and its existence confirmed by repeated experiment, the principles involved are not completely understood. It has been determined that the greatest forces are developed when the leading electrode is made positive with respect to the body 20, and it is accordingly thought that in the immediate vicinity of the electrode 21 where the potential gradient is very high, free electrons are stripped off of the atoms and molecules of the surrounding medium. These electrons migrate to the positive electrode 21 where they are collected. This removal of free electrons leaves the respective atoms and molecules positively charged and such charged atoms and molecules are accordingly repelled from the positive electrode 21 and attracted toward the negative electrode 20. The paths of movement of these positively charged particles appear to be of the nature represented by the lines 27 in Figure 2.

It appears that upon reaching or closely approaching the surface of the body 20, the positively charged atoms and molecules have their positive charges neutralized by the capture of electrons from the body 20 and in many cases, it may be that excess electrons are captured whereby to give such atoms and molecules a negative charge so that they are actually repelled from the body 20.

It will be appreciated that the mass of each of the individual electrons is approximately one two-thousandths the mass of the hydrogen atom and is accordingly negligible as compared with the mass of the atoms and molecules of the medium from which they are taken. The principal forces involved therefore are the forces involved in moving the charged atoms and molecules from the region of the positive electrode 21 to and beyond the negatively charged body 20. The force so exerted by the system on those atoms and molecules not only produces a flow of the medium relative to the apparatus, but, of course, results in a like force on the system tending to move the entire system in the opposite direction; that is, to the left as viewed in Figure 1 of the drawing.

The above suggested explanation of the mode of operation of the device is supported by observation of the fact that the dimensions and potentials utilized must be adjusted to produce the required electric field and the resulting propulsive force. Actually I have found that the potential gradient must be below that value required to produce a visible corona since corona is objectionable inasmuch as it represents losses through the radiation of heat, light and molecular charges in the medium.

My experiments have indicated that the electrode 21 may be of small diameter for the lower voltage ranges, i.e. below 125 kv. while above this voltage, rod or hollow pipe electrodes are preferred. These large electrodes are preferred for the higher voltages since sharp points or edges are eliminated which at these elevated potentials would produce losses thus diminishing the thrust. For example, electrodes to be operated at potentials below 125 kv. may be made from small gauge wire only large enough to provide the required mechanical rigidity while

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electrodes to be operated at potentials above 125 kv. may be hollow pipes or rods having a diameter of ¼ to ½ inch.

In Figure 3, I have illustrated the manner in which a plurality of assemblies, such as are shown in Figure 1, may be interconnected for joint operation. As may be seen from Figure 3, a plurality of such assemblies are placed in spaced side-by-side relation. They may be held fixed in such spaced relation through the use of a plurality of tie rods 28 and interposed spacers (not shown) placed between adjacent plates 20. The assembly of plates 20 may be electrically interconnected by a bus bar or similar conductor 29 to which the negative lead 25 is connected. In a similar way, the plurality of positive leading electrodes 21 may be held in appropriately spaced relation to each other by fastening their ends to pairs of bus bars 30 and 31, to the latter of which the positive lead 26 is connected. The assembly of leading electrodes 21 may be held in spaced relation to the assembly of body members 20 by an appropriate arrangement of the supports 22.

In Figure 4, I have illustrated diagrammatically an arrangement of parts for producing a reversible action; that is, permitting the direction of the propulsive force to be reversed. The apparatus is similar to that shown in Figure 1, differing therefrom in utilizing a pair of leading electrodes 21*f* and 21*r* spaced by means of spacers 22 from the front and rear edges 23*f* and 23*r* of the body member 20 in a manner similar to that described with reference to the supports 22 in Figure 1. The source 24 of high voltage electrical potential has its negative terminal connected to the body 20 as by means of the aforementioned conductor 25. The positive terminal is connected as by means of the conductor 26 to the blade 27 of a single-pole, double-throw switch, serving in one position to connect the conductor 26 to a conductor 26*f* which is in turn connected to the forward electrode 21*f* and arranged in its opposite position to connect the conductor 26 to a conductor 26*r* which is in turn connected to the reverse electrode 21*r*.

It will be seen that with the switch 27 in the position shown in Figure 4, the apparatus will operate in the manner described in connection with Figure 1, causing the assembly to move to the left as viewed in Figure 4. By throwing the switch 27 to the opposite position, the direction of the forces produced are reversed and the device moves to the right as viewed in Figure 4.

In Figure 5, I have illustrated the principles of the invention as embodied in a simple form of mobile vehicle. This device includes a body member 50 which is preferably of the form of a circular disc somewhat thicker in its center than at its edges. The disc 50 constitutes one of the electrodes and is the equivalent of the body member 20 referred to in connection with Figure 1. A leading electrode 51 in the form of a wire or similar small diameter conductor is supported from the body 50 by a plurality of insulating supports 52 in uniform spaced parallel relation to a leading edge portion 53 of the body 50. A skirt or similar fairing 54 may be carried by the body 50 to round out the entire structure so as to provide a device which is substantially circular in plan. A source of high voltage electrical potential 55 is provided with its negative terminal connected as indicated at 56 to the body 50 and its positive terminal connected as indicated at 57 to the leading electrode 51.

The device operates in the same manner as the apparatus shown in Figure 1 to produce a force tending to move the entire assembly through the surrounding medium to the left as viewed in Figure 5 of the drawing.

Referring now to Figure 6, there is depicted an illustrative embodiment of this invention in which a pair of mobile vehicles, such as depicted in Figure 5, are shown suspended from the terminals of arm 40, which arm is supported at its midpoint by a vertical column 41. High voltage source 55 is shown connected through wires

Figure 3. Excerpt from Thomas Townsend Brown's U.S. Patent No. 2,949,550, entitled "Electrokinetic Apparatus," issued on August 16, 1960.

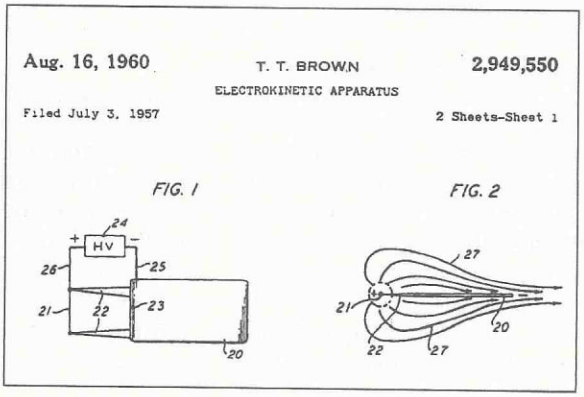

Figure 4. Figures excerpted from Thomas Townsend Brown's U.S. Patent No. 2,949,550, entitled "Electrokinetic Apparatus," issued on August 16, 1960.

electrodes. (This is reminiscent of Faraday's law of induction.) Figure 5 is an excerpt from the 1962 patent by Thomas Townsend Brown.

Until this time, the net force on an asymmetric capacitor was reported as occurring when the capacitor was in a dielectric medium. On May 9, 1958, Brown filed for another patent (improving upon his previous work) entitled "Electrokinetic Apparatus." The patent was issued on June 1, 1965 as Patent No. 3,187,206. The significance of this new patent is that it describes the existence of a net force on the asymmetric capacitor as occurring even in vacuum. Brown states that, "The propelling force however is not reduced to zero when all environmental bodies are removed beyond the apparent effective range of the electrical field." (See Figure 6.)

In this patent, Brown reports that the asymmetric capacitor does show a net force, even in vacuum. However, at present, there is little experimental evidence, except for two reports[2] which do not explain the origin of the observed force, and two theoretical papers.[3,4] If the Biefeld-Brown effect is to be understood on a firm basis, it is imperative to determine whether the effect occurs in vacuum. Enclosed in Appendix B is Bahder's email correspondence with J. Naudin, where Naudin quotes from a letter by Thomas Townsend Brown, who discusses the effect in vacuum.

The main question to be answered is: what is the physical mechanism that is responsible for the net force on an asymmetric capacitor? The answer to this question may depend on whether the asymmetric capacitor is in a polarizable medium (such as air), or in vacuum. However, to date, the physical mechanism is unknown, and until it is understood, it will be impossible to determine its potential for practical applications.

3. Preliminary Experiments at ARL

The Biefeld-Brown effect is reported in many places on the Internet; however, as mentioned above, only two papers exist.[3,4] Therefore, we decided to verify that the effect was real. C. Fazi (ARL) and T. Bahder (ARL) have fabricated three simple asymmetric capacitors, using the designs reported on the Internet.[1] In all three cases, we have verified that a net force is exerted on the capacitors when a high DC voltage is applied to the electrodes. The three asymmetric capacitors that we tested had different geometries, but they all had the common feature that one electrode was thin and the other very wide (asymmetric dimensions). Also, a suspended wire, representing a capacitor with the second electrode at infinity, showed lift.

Our first model was made by Tom Bahder, and was triangular in shape, which is a typical construction reported on the Internet (Figure 7). One electrode is made from thin 38-gauge (0.005-mil) wire, and the other electrode is made from ordinary aluminum foil. The capacitor is ~20 cm on a side, the foil sides are 20 cm x 4 cm, and the distance of the top of the foil to the thin wire electrode is 3 cm. The foil and wire are supported by a Balsa wood frame, so that the whole capacitor is very light, ~5 g. Initially, we made the Balsa wood frame too heavy (capacitor weight ~7 g), and later we cut away much of the frame to lighten the construction to ~5 g. We found that in order to demonstrate the lifting effect, the capacitor must be made of minimum weight. (Typical weights reported on the Internet for the design in Figure 7 are 2.3 g–4 g.)

When ~37 kV was applied to the capacitor in Figure 7, the current was ~1.5 mA. The capacitor lifted off its resting surface.

> This invention utilizes heretofore unknown electrokinetic phenomenon which I have discovered, namely that when pairs of electrodes of appropriate form are held in a certain fixed spacial relationship to each other and immersed in a dielectric medium and then oppositely charged to an appropriate degree, a force is produced tending to move the surrounding dielectric with respect to the pair of electrodes. I have also discovered that if the dielectric medium is moved relative to the pairs of electrodes by an external mechanical force, a variation in the potential of the electrodes results which variation corresponds to the variations in the applied mechanical force.
>
> Accordingly, it is an object of this invention to provide a method and apparatus for converting the energy of an electrical potential directly into a mechanical force suitable for causing relative motion between a structure and the surrounding medium.

Figure 5. Excerpt from Thomas Townsend Brown's U.S. Patent No. 3,018,394, entitled "Electrokinetic Transducer," issued on January 23, 1962.

> **3,187,206**
> **ELECTROKINETIC APPARATUS**
> **Thomas Townsend Brown, Walkertown, N.C., assignor, by mesne assignments, to Electrokinetics, Inc., a corporation of Pennsylvania**
> **Filed May 9, 1958, Ser. No. 734,342**
> **23 Claims. (Cl. 310—5)**
>
> This invention relates to an electrical device for producing thrust by the direct operation of electrical fields.
>
> I have discovered that a shaped electrical field may be employed to propel a device relative to its surroundings in a manner which is both novel and useful. Mechanical forces are created which move the device continuously in one direction while the masses making up the environment move in the opposite direction.
>
> When the device is operated in a dielectric fluid medium, such as air, the forces of reaction appear to be present in that medium as well as on all solid material bodies making up the physical environment.
>
> In a vacuum, the reaction forces appear on the solid environmental bodies, such as the walls of the vacuum chamber. The propelling force however is not reduced to zero when all environmental bodies are removed beyond the apparent effective range of the electrical field.
>
> By attaching a pair of electrodes to opposite ends of a dielectric member and connecting a source of high electrostatic potential to these electrodes, a force is produced in the direction of one electrode provided that electrode is of such configuration to cause the lines-of-force to converge steeply upon the other electrode. The force, therefore, is in a direction from the region of high flux density toward the region of low flux density, generally in the direction through the axis of the electrodes. The thrust produced by such a device is present if the electrostatic field gradient between the two electrodes is non-linear. This non-linearity of gradient may result from a difference in the configuration of the electrodes, from the electrical potential and/or polarity of adjacent bodies, from the shape of the dielectric member, from a gradient in the density, electric conductivity, electric permittivity and manetic permeability of the dielectric member or a combination of these factors.

Figure 6. Excerpt from Thomas Townsend Brown's Patent No. 3,187,206, entitled, "Electrokinetic Apparatus," issued on June 1, 1965.

However, this capacitor was not a vigorous flier, as reported by others on the Internet. One problem that occurred was arcing from the thin wire electrode to the foil. The thin wire electrode was too close to the foil. We have found that arcing reduces the force developed on the capacitor. Also, compared to other constructions, ours was too heavy, 5 g. We found that a ground plane beneath the capacitor is not essential for the lifting force to exceed the capacitor's weight.

Consequently, we decided to make a second version of an asymmetric capacitor, using a Styrofoam lunch box and plas-

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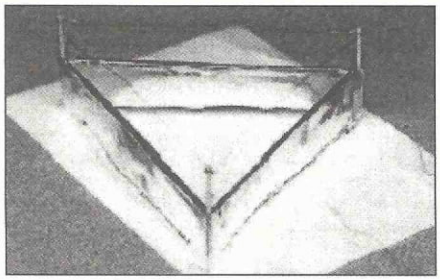

Figure 7. Our first attempt at making an asymmetric capacitor (a "lifter"), according to the specifications given by J. Naudin on his website, http://jnaudin.free.fr/.

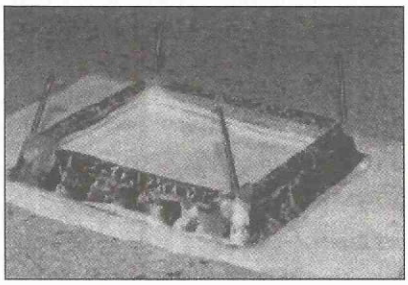

Figure 8. The second attempt at making a lighter asymmetric capacitor.

tic drinking straws from the ARL cafeteria (Figure 8). The capacitor had a square geometry, 18 cm x 20 cm. The distance of the thin wire (38 gauge) to the foil was adjustable, and we found that making a 6-cm gap resulted in little arcing. When 30 kV was applied, the capacitor drew ~1.5 mA, and hovered vigorously above the floor.

A question occurred: is the toroidal (closed circular) geometry of the capacitor electrodes essential to the lifting effect that we have observed? Consequently, Tom Bahder made a flat-shaped, or wing-shaped, capacitor, as shown in Figure 9. This capacitor was made from two (red) plastic coffee stirrers and a (clear) plastic drinking straw to support the aluminum foil. The significance of the clear plastic straw was that the foil could be wrapped over it, thereby avoiding sharp foil edges that would lead to corona discharge or arcing. The dimensions of the foil on this capacitor were 20 cm x 4 cm, as shown in Figure 9. The distance between the thin wire electrode (38 gauge wire) and edge of the foil was 6.3 cm. This capacitor showed a net force on it when ~30 kV was applied, drawing ~500 mA. The force on this capacitor greatly exceeded its weight, so much so that it would vigorously fly into the air when the voltage was increased from zero. Therefore, we have concluded that the closed geometry of the electrodes is not a factor in the net force on an asymmetric capacitor. Furthermore, the force on the capacitor always appeared in the direction toward the small electrode—independent of the orientation of the capacitor with respect to the plane of the Earth's surface. The significance of this observation is that the force has nothing to do with the gravitational field of the Earth and nothing to do with the electric potential of the Earth's atmosphere. (There are numerous claims on the Internet that asymmetric capacitors are antigravity devices, or devices that demonstrate that there is an interaction of gravity with electric phenomena.)

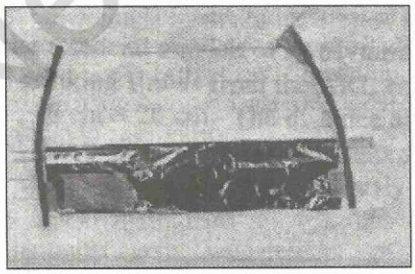

Figure 9. Flat-shaped (or wing-shaped) asymmetric capacitor used to test whether closed electrode geometry is needed.

The thin wire electrode must be at a sufficient distance away from the foil so that arcing does not occur from the thin wire electrode to the foil at the operating voltage. In fact, in our first model, shown in Figure 7, the 3-cm gap from top of the foil to thin wire electrode was not sufficiently large, and significant arcing occurred. We have found that when arcing occurs, there is little net force on the capacitor. An essential part of the design of the capacitor is that the edges of the foil, nearest to the thin wire, must be rounded (over the supporting Balsa wood, or plastic straw, frame) to prevent arcing or corona discharge at sharp foil edges (which are closest to the thin wire). The capacitor in Figure 7 showed improved lift when rounded foil was put over the foil electrode closest to the thin wire, thereby smoothing-over the sharp foil edges. Physically, this means that the radius of curvature of the foil nearest to the small wire electrode was made larger, creating a greater asymmetry in radii of curvature of the two electrodes.

When operated in air, the asymmetric capacitors exhibit a net force toward the smaller conductor, and in all three capacitors, we found that this force is independent of the DC voltage polarity.

The detailed shape of the capacitor seems immaterial, as long as there is a large asymmetry between the characteristic size of the two electrodes. The simplest capacitor configuration consists of a suspended thin wire from the hot electrode of the high-voltage power supply, as shown in Figure 10. To observe the wire movement, a small piece of transparent tape was attached at the lower end of the thin wire. A suspended thin wire (~12 in length) also showed force with ~35 kV and 1 mA current (Figure 9). From a vertical position, the wire lifted, as shown in Figure 11, by as much as 30°, once the high voltage approached 35 kV. The usual air breakdown hissing sound of the other capacitors was heard when current reached ~1 mA. Actually, the wire did not remain suspended, but oscillated back and forth approximately 60° from vertical, and the hissing pitch followed the oscillation period with amplitude and frequency changes. Without the piece of tape at the end, the wire did not lift as much and the sound was considerably weaker. The piece of tape seems to increase the capacitance and/or the air ionization. This suspended wire configuration can also be viewed as a capacitor surrounded by the ground system located several feet away (metallic benches, floor, and ceiling). As in the other capacitor experiments, it also did not exhibit a polarity dependence.

When the asymmetric capacitors have an applied DC voltage, and they are producing a net force in air, they all emit a peculiar hissing sound with pitch varying with the applied voltage. This sound is similar to static on a television or radioset when it is not tuned to a good channel. We believe that this sound may be a clue to the mechanism responsible for the net force.

4. Previously Proposed Explanations for the Biefeld-Brown Force

There are two proposed explanations for the Biefeld-Brown force. Both of these have been discussed on the Internet in various places. The first proposed scheme is that there exists an ionic wind in the high field region between the capacitor

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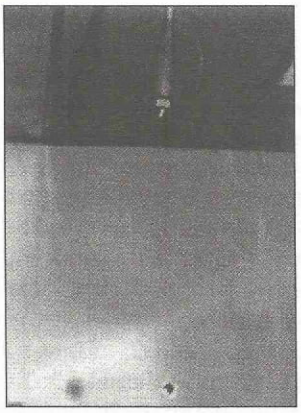

Figure 10. The capacitor consisting of a single wire. No bias applied.

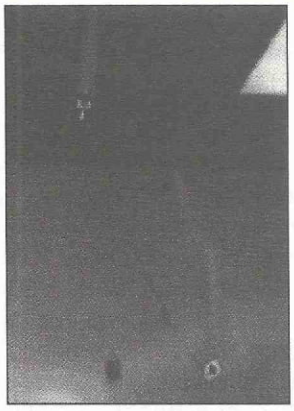

Figure 11. The wire capacitor showing displacement from the vertical. 35 kV applied.

electrodes, and that this ionic wind causes the electrodes to move as a result of the momentum recoil. This scheme, described in Section 4.1, leads to a force that is incorrect by at least three orders of magnitude compared to what is observed. (This scheme also assumes ballistic transport of charges in the atmosphere between electrodes of the capacitor, and it is known that instead drift current exists.)

In Section 4.2, we present the second scheme, which assumes that a drift current exists between the capacitor plates. This scheme is basically a scaling argument, and not a detailed treatment of the force. In this scheme, the order of magnitude of the force on an asymmetric capacitor is correct, however, this scheme is only a scaling theory. Finally, in Section 5, we present our thermodynamic treatment of the force on an asymmetric capacitor.

4.1. Ionic Wind: Force Too Small

The most common explanation for the net force on an asymmetric capacitor invokes ionic wind. Under a high-voltage DC bias, ions are thought to be accelerated by the high potential difference between electrodes, and the recoil force is observed on an asymmetric capacitor. A simple upper limit on the ion wind force shows that the ion wind effect is at least three orders of magnitude too small. Consider a capacitor that operates at voltage V. Charged particles of mass m, having charge q, such as electrons or (heavy) ions, are accelerated to a velocity v, having a kinetic energy

$$\frac{1}{2}mv^2 = qV. \tag{1}$$

The force exerted on an asymmetric capacitor is given by the rate of change of momentum

$$F = mv\frac{I}{q}, \tag{2}$$

where I is the current flowing through the capacitor gap, and we assume that all the ionic momentum, mv, is transferred to the capacitor when the charged particles leave an electrode. Also, we assume that none of this momentum is captured at the other electrode. This is a gross over-estimation of the force due to ionic effects, so Equation (2) is an upper limit to the ionic force.

Solving Equation (1) for the velocity, and using it in Equation (2) gives the upper limit on the force due to ionic wind

$$F = \left(\frac{2mV}{q}\right)^{\frac{1}{2}} I. \tag{3}$$

When the force F is equal to the weight of an object, Mg, where g is the acceleration due to gravity, the force will lift a mass

$$M = \left(\frac{2mV}{q}\right)^{\frac{1}{2}} \frac{I}{g}. \tag{4}$$

If we assume that electrons are the charged particles responsible for force of the ionic wind, then we must use mass m = 9.1 x 10^{-31} kg. Substituting typical experimental numbers into Equation (4), we find that the ionic wind can lift a mass

$$M = \left(\frac{(2)(9.1\times10^{-31}\text{kg})(40\times10^{3}\text{ Volt})}{1.6\times10^{-19}\text{ C}}\right)^{\frac{1}{2}} \frac{1.0\times10^{-3}\text{ A}}{10\,\frac{\text{m}}{s^2}} = 6.8\times10^{-5}\text{ gram}. \tag{5}$$

The typical weight of an asymmetric capacitor is on the order of 5 g, so this force is too small by five orders of magnitude.

Another possibility is that heavy ions (from the air or stripped off the wire) are responsible for the ionic wind. As the heaviest ions around, assume that Cu is being stripped from the wire. Using Cu for the ions, the mass of the ions is 63.55 m_p, where 63.55 is the atomic mass of Cu and m_p is the mass of a proton. The weight that could be lifted with Cu ionic wind is then (upper limit):

$$M = \left(\frac{(2)(63.55)(1.67\times10^{-27}\text{kg})(40\times10^{3}\text{ Volts})}{1.6\times10^{-19}\text{ C}}\right)^{\frac{1}{2}} \frac{1.0\times10^{-3}\text{ A}}{10\,\frac{\text{m}}{s^2}} = 0.002\text{ gram} \tag{6}$$

Again, this value is three orders of magnitude too small to account for lifting a capacitor with a mass of 3-5 g. Therefore, the ionic wind contribution is too small, by at least three orders of magnitude, to account for the observed force on an asymmetric capacitor.

While the force of the ionic wind computed above is too small to explain the experiments in air, it should be noted that this effect will operate in vacuum, and may contribute to the overall force on a capacitor.

4.2. The Ion Drift Picture: Scaling Theory of Force

In the previous section, we computed an upper limit to the force on a capacitor due to ionic wind effects. Ionic wind is a ballistic flow of charges from one electrode to the other. Clearly the force due to ionic wind is at least three orders of magnitude too small to account for the observed force on an asymmetric capacitor (in air). There is another type of classical transport: drift of charge carriers in an electric field. In the case of drift, the carriers do not have ballistic trajectories, instead they experience collisions on their paths between electrodes. However, due to the presence of an electric field, the carriers have a net motion toward the opposite electrode.

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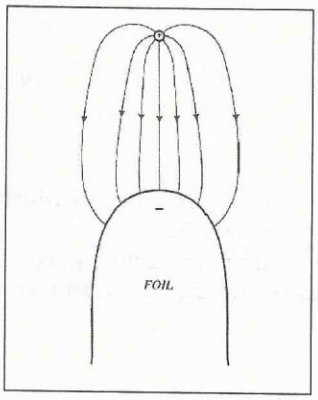

Figure 12. Schematic diagram of the side view of electric field for the asymmetric capacitor in Figure 9.

This type of transport picture is more accurate (than ballistic ionic wind) for a capacitor whose gap contains air. Drift transport is used by Evgenij Barsoukov to explain the net force on an asymmetric capacitor.[5]

The general picture of the physics is that the positive and negative electrodes of the capacitor are charged and that these charges experience different forces because the electric field surrounding the capacitor is nonuniform (Figure 12). The electric field surrounding the capacitor is created by the potential applied to the capacitor electrodes and partial ionization of air into positive ions and electrons. These charge carriers experience drift and diffusion in the resulting electric field. The battery supplies the energy that is dissipated by transport of carriers in the electric field. The electric field is particularly complicated because it is the result of a steady state: the interplay between the dynamics of ionization of the air in the high-field region surrounding the electrodes and charge transport (drift and diffusion of positive and negative carriers) in the resulting electric field.

If the capacitor is surrounded by vacuum (rather than a dielectric, such as ions on air), the net force F on the asymmetric capacitor can be computed by the sum of two surface integrals, one over the surface of the positive electrode and one over the surface of the negative electrode:[6]

$$F = \frac{1}{2}\varepsilon_0 \left(\int_{S_-} E^2 \, \mathbf{n} \, dS + \int_{S_-} E^2 \, \mathbf{n} \, dS \right), \tag{7}$$

where ε_0 is the permittivity of vacuum, E is the electric field normal to the conducting electrodes, S_+ and S_- are the positive and negative electrode surfaces of the capacitor and $\mathbf{n}$ is the outward normal to S_+ and S_-. The integrals in Equation (7) are done over closed surfaces S_+ and S_-. As stated above, the complexity of the calculation is contained in computing the electric field E. In Section 5, we give an expression for the net force on the capacitor assuming that it is surrounded by a dielectric, such as air.

The electric field around the small wire electrode is much stronger than the field around the foil (see Figures 9 and 12). In our experiments, there is a big difference in the radii of curvature of the two capacitor electrodes: the thin wire electrode has a radius r_1= 0.0025 inch, and the edge of the foil has a radius of curvature of r_2 = 0.125 inch. This difference in curvature leads to an electric field with a strong gradient. The ratios of electric fields at the thin wire electrode to that at the rounded edge of the foil is inversely proportional to the square of the radii of curvatures: $E_1/E_2 = (r_1/r_2)^2 \sim 2500$. However, the applied voltage is on the order of 30 kV, over a gap of 6 cm, so an electric field of magnitude 2500 x 30 kV/6 cm ~ 1 x $10^7 \frac{V}{\text{cm}}$ would not be supported in air. It is clear that screening of the electric field is occurring due to the dielectric effects of charged air ions and electrons, as well as polarized air atoms. When a positive high voltage is applied to the thin wire electrode of the asymmetric capacitor, ionization of air atoms, such as nitrogen, probably occurs first near the thin wire electrode. The ionization of nitrogen atoms leads to free electrons and ions near the small electrode. The electron mobility is significantly larger for electrons than for nitrogen ions. This can be expected because the current density $J = \sigma E = n e v$ where $\sigma = n e^2 \tau / m$ is the electrical conductivity, n is charge density, τ is the scattering time, and the mean drift velocity $v = \mu E$. So the mobility behaves as $\mu = e \tau / m$. Because electrons are three orders of magnitude more massive than ions, it is expected that they are correspondingly more mobile. Experimentally, it is found that the electron mobility in air at atmospheric pressure and electric field $E = 10^4$ Volt/cm is approximately[7]

$$\mu_e = 620 \frac{\text{cm}^2}{\text{Volt} \cdot \text{sec}}. \tag{8}$$

The mobility of N_2 ions in air is[8]

$$\mu_{N_2} = 2.5 \frac{\text{cm}^2}{\text{Volt} \cdot \text{sec}}. \tag{9}$$

Therefore, the physical picture is that in the high field region the electrons, with their high mobility, are swept out by the electric field, toward the thin wire electrode leading to screening of the field. The massive (probably positive) ions are less mobile and are left behind in a plasma surrounding the thin wire electrode.

A scaling argument can be made as follows: The lower foil conductor feels a force F of magnitude

$$F = Q \frac{V}{\ell}, \tag{10}$$

where Q is the charge on the foil electrode, V is the voltage between the capacitor conductors, and l is the length of the gap between thin wire electrode and foil. The charge Q and voltage V are quantities that are actually present when screening is taking place. The negative charge on the foil, $-Q$, can be approximated in terms of the measured current, $I \sim 1$mA, by saying that all the carriers are swept out in a time t:

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$$I = \frac{Q}{t} = Q\frac{v}{\ell}, \tag{11}$$

where t is the time for carriers to move across the capacitor gap, l, if they are travelling at an average drift velocity, v. Eliminating the charge Q from Equations (10) and (11) leads to an expression for the net force on the capacitor

$$F = I\frac{V}{v}. \tag{12}$$

In Equation (12), the current I is a measured quantity, the voltage V is on the order of 30 kV, and the drift velocity for electrons is[7]

$$v_e = 6.2 \times 10^6 \ \frac{\text{cm}}{\text{sec}}. \tag{13}$$

Alternatively, the electron drift velocity, v_e, can be expressed in terms of the mobility, μ_e, given in Equation (8), and electric field, E. The net force on the asymmetric capacitor is then given by

$$F = I\frac{V}{\mu E} = I\frac{l}{\mu} \tag{14}$$

where we again used $E = V/l$. Using the value of electron mobility in Equation (8), the net force becomes

$$F = I\frac{l}{\mu} = \frac{(10^{-3}\ \text{A})(0.04\ \text{m})}{\left(620\ \frac{\text{cm}^2}{\text{Volt}\cdot\text{sec}}\right)\left(10^{-2}\ \frac{\text{m}}{\text{cm}}\right)^2} = 6.4 \times 10^{-4}\,\text{N}. \tag{15}$$

The force in Equation (15) could lift a mass M

$$M\frac{F}{g} = \frac{6.4 \times 10^{-4}\,\text{N}}{10\ \frac{\text{m}}{\text{s}^2}} = 0.064\ \text{gram}. \tag{16}$$

The typical asymmetric capacitor has a mass that is two orders of magnitude greater. Consequently, drift of electrons cannot explain the observed force on the capacitor.

An alternative to using the value of electron mobility is to use the smaller value of ionic mobility. This will lead to a larger force because the force in Equation (14) is inversely proportional to the mobility.

$$F = I\frac{l}{\mu} = \frac{(10^{-3}\ \text{A})(0.04\ \text{m})}{\left(2.5\ \frac{\text{cm}^2}{\text{Volt}\cdot\text{sec}}\right)\left(10^{-2}\ \frac{\text{m}}{\text{cm}}\right)^2} = 0.16\ \text{N}. \tag{17}$$

The force in Equation (17), due to the drift of nitrogen ions, could lift a mass M:

$$M = \frac{F}{g} = \frac{0.16\ \text{N}}{10\ \frac{\text{m}}{\text{s}^2}} = 16\ \text{gram}. \tag{18}$$

The force on the capacitor, given in Equation (18), is within a factor of 3, assuming a capacitor of mass 5 g.

As alternative derivation of the scaling Equation (14), consider the asymmetric capacitor as being essentially an electric dipole of magnitude,

$$|\mathbf{p}| = p = Ql, \tag{19}$$

where Q is the charge on one plate and l is the average effective separation between plates. When a high voltage is applied to the asymmetric capacitor (assume positive voltage on the thin wire and negative on the foil), the high electric field around the thin wire ionizes the atoms of the air. There is comparatively little ionization near the foil due to the lower magnitude electric field near the foil. The ionized atoms around the foil form a plasma, consisting of charged electrons and positively charged ions. The force on the capacitor must scale like

$$\mathbf{F} = \nabla(\mathbf{p}\cdot\mathbf{E}) \tag{20}$$

where E is the electric field. The gradient operates on the electric field, producing a magnitude $dE/dx \sim E/l$. Using this value in Equation (20), together with the size of the dipole in Equation (19), leads to a force on the capacitor

$$F = Q\frac{V}{\ell} \sim \frac{I\ell}{v}\cdot\frac{V}{\ell} = I\frac{V}{v}, \tag{21}$$

which is identical to Equation (12).

From the scaling derivations that were presented, it is clear that electron drift current leads to a force on the capacitor that is too small. Using the value of mobility appropriate for (nitrogen) ions leads to a force whose order of magnitude is in agreement with experiment.

Note that the force, given by Equation (14), scales inversely with the mobility μ. If the ions are responsible for providing the required small mobility, then the picture is that the ions are like a low-mobility molasses, which provides a large spacecharge to attract the negatively charged foil electrode. As soon as the foil electrode moves toward the positive ion cloud, another positive ionic cloud is set up around the thin electrode, using the energy from the voltage source. In this way, the dipole (asymmetric capacitor) moves in the nonuniform electric field that it has created. Physically, this is a compelling picture; however, much work must be done (experimentally and theoretically) to fill in important details to determine if this picture has any merit.

5. Thermodynamic Analysis of the Biefeld-Brown Force

In this section, we present our hypothesis that the Biefeld-

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Brown force, generated on an asymmetric capacitor, can be described by the thermodynamics of a fluid dielectric in an external electric field produced by charged conductors. The (partially ionized) air between capacitor electrodes is the fluid dielectric. Although the air is partially ionized, we assume that this fluid dielectric is close to neutral on the macroscopic scale. The charged conductors are the asymmetric electrodes of the capacitor. The battery provides the charge on the electrodes and the energy to sustain the electric field in the air (dielectric) surrounding the capacitor electrodes.

The total system is composed of three parts: the partially ionized air dielectric, the metal electrodes of the capacitor and the battery (voltage source) and connecting wires, and the electromagnetic field. The battery is simply a large reservoir of charge. The total momentum (including the electromagnetic field) of this system must be constant:[9]

$$\mathbf{P}_{\text{dielectric}} + \mathbf{P}_{\text{electrodes}} + \mathbf{P}_{\text{field}} = \text{constant}, \tag{22}$$

where $\mathbf{P}_{\text{dielectric}}$ is the momentum of the fluid dielectric (air in the capacitor gap and surrounding region), $\mathbf{P}_{\text{electrodes}}$ is the momentum of the metallic electrodes, wire and battery, and $\mathbf{P}_{\text{field}}$ is the momentum of the electromagnetic field. Taking the time derivative of Equation (22), the forces must sum to zero

$$\mathbf{F}_{\text{dielectric}} + \mathbf{F}_{\text{electrodes}} + \frac{d\mathbf{P}_{\text{field}}}{dt} = 0. \tag{23}$$

As far as the electric field is concerned, its total momentum changes little during the operation of the capacitor, because the field is in a steady state; energy is supplied by the battery (charge reservoir). So we set the rate of change of field momentum to zero, giving a relation between the force on the electrodes and the dielectric:

$$\mathbf{F}_{\text{electrodes}} = -\mathbf{F}_{\text{dielectric}}. \tag{24}$$

A lengthy derivation based on thermodynamic arguments leads to an expression for the stress tensor, σ_{ik}, for a dielectric medium in an electric field[6,10,11]

$$\sigma_{ik} = \left[\tilde{F} - \rho\left(\frac{\partial \tilde{F}}{\partial \rho}\right)_{T,\mathbf{E}}\right]\delta_{ik} + E_i D_k, \tag{25}$$

where the free energy $\tilde{F}$ is a function of the fluid density, ρ, temperature, T, and electric field E. The differential of the free energy is given by

$$d\tilde{F} = -S\,dT + \zeta\,d\rho - \mathbf{D}\cdot d\mathbf{E}, \tag{26}$$

where S is the entropy, D is the electric induction vector, and ζ is the chemical potential per unit mass.[6] Equation (25) is valid for any constitutive relation between D and E. We assume that the air in between the capacitor plates is an isotropic, but nonlinear, polarizable medium, due to the high electric fields between plates. Therefore, we take the relation between D and E to be

$$\mathbf{D} = \varepsilon(E)\mathbf{E}, \tag{27}$$

where $\varepsilon(E)$ is a scalar dielectric function that depends on the magnitude of the electric field, $E = |\mathbf{E}|$, the temperature, T, and the density of the fluid, ρ. We have suppressed the dependence of ε on T and ρ for brevity. The dielectric function $\varepsilon(E)$ depends on position through the variables T and ρ and because the medium (air) between capacitor plates is assumed to be non-uniform. Inserting Equation (27) into Equation (26), we integrate the free energy along a path from $E = 0$ to some finite value of E obtaining

$$\tilde{F}(\rho,T,\mathbf{E}) = \tilde{F}_o(\rho,T) - \frac{1}{2}\varepsilon_{\text{eff}}\,E^2 \tag{28}$$

where ε_{eff} is an effective (averaged) dielectric constant, given by

$$\varepsilon_{\text{eff}} = \frac{1}{E^2}\int_0^{E^2}\varepsilon\left(\sqrt{\xi}\right)d\xi \tag{29}$$

where ξ is a dummy integration variable. The dielectric constant ε_{eff} depends on spatial position (because of ε), on T, ρ, and on electric field magnitude E.

The body force per unit volume of the dielectric, f_i, is given by the divergence of the stress tensor,

$$f_i = \frac{\partial \sigma_{ik}}{\partial x_k}, \tag{30}$$

where there is an implied sum over the repeated index k. Performing the indicated differentiations in Equation (30), we obtain an expression for the body force[6,10,11]

$$\mathbf{f} = -\nabla P_o(\rho,T) + \frac{1}{2}\nabla\left[E^2\rho\left(\frac{\partial\varepsilon_{\text{eff}}}{\partial\rho}\right)_{T,\mathbf{E}}\right] - \frac{1}{2}E^2\nabla\varepsilon_{\text{eff}} + \frac{1}{2}(\varepsilon - \varepsilon_{\text{eff}})\nabla E^2 + \rho_{\text{ext}}\mathbf{E}, \tag{31}$$

where the external charge density is give by div $\mathbf{D} = \rho_{\text{ext}}$. This charge density is the overall external charge density in the dielectric, which may have been supplied by the battery, electrodes, and the surrounding air. In Equation (31), the pressure $P_o(\rho, T)$ is that which would be present in the absence of the electric field. In the case of a linear medium, the dielectric function ε is independent of field E, and $\varepsilon_{\text{eff}} = \varepsilon$, which reduces to the result derived by Landau and Lifshitz (see their Equations (15.12) in Reference 6).

The total force on the fluid dielectric, $\mathbf{F}_{\text{dielectric}}$, is given by the volume integral of f over the volume of the dielectric, Ω:

$$\mathbf{F}_{\text{dielectric}} = \int_\Omega \mathbf{f}\,dV \tag{32}$$

The volume Ω is the whole volume outside the metal electrodes of the capacitor. According to Equation (24), the net force on the capacitor, $\mathbf{F}_{\text{electrodes}}$, is the negative of the total force on the dielectric:

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$$\mathbf{F}_{\text{electrodes}} = \int_{\Omega} \left\{ \frac{1}{2} E^2 \nabla \varepsilon + \frac{1}{2} \nabla \left[(\varepsilon_{\text{eff}} - \varepsilon) E^2 \right] - \frac{1}{2} \nabla \left[E^2 \rho \left(\frac{\partial \varepsilon_{\text{eff}}}{\partial \rho} \right)_{T,\mathbf{E}} \right] - \rho_{\text{ext}} \mathbf{E} \right\} dV, \quad (33)$$

where we have dropped the term containing the gradient in the pressure, assuming that it is negligible. Equation (33) gives the net force on capacitor plates for the case where the fluid dielectric is nonlinear, having the response given in Equation (27). In Equation (33), both ε and ε_{eff} are functions of the electric field. Note that the first three terms of the integrand depend on the square of the electric field, which is in agreement with the fact that the observed force direction is independent of the polarity of the applied bias.

There are four terms in the force. The first term is proportional to the gradient of the dielectric constant, $\nabla\varepsilon$. We expect that the dielectric constant has a large variation in between regions of low and high electric field, such as near the smaller electrode. We expect that there is a strong nonlinear dielectric response due to ionization of the air. The resulting free charges can move large distances, leading to a highly nonlinear response at high electric fields. Therefore, it is possible that this first term in the integrand in Equation (33) has the dominate contribution. We expect this term to contribute to a force that points toward the smaller electrode (as observed experimentally), and we expect that this contribution is nearly independent of polarity of applied bias.

The second term in the force Equation (33) is proportional to the gradient of the product of the square of the electric field and the difference in dielectric constants. The difference in the dielectric constants, $\varepsilon_{\text{eff}} - \varepsilon$, can be expanded in a Tavlor series in E

$$\varepsilon_{\text{eff}} - \varepsilon = -\frac{1}{3} \varepsilon'(0) E - \frac{1}{4} \varepsilon''(0) E^2 + \ldots, \quad (34)$$

where

$$\varepsilon'(0) = \left(\frac{\partial \varepsilon}{\partial E} \right)_{T,\rho,\mathbf{E}=0}, \text{ and}$$

$$\varepsilon''(0) = \left(\frac{\partial^2 \varepsilon}{\partial E^2} \right)_{T,\rho,\mathbf{E}=0}. \quad (35)$$

The gradient of the square of the electric field always points toward the smaller electrode, independent of the polarity of bias applied to the capacitor. We do not know the sign of the dielectric constants $\varepsilon'(0)$ and $\varepsilon''(0)$. If the air has dielectric properties described by $\varepsilon'(0) < 0$ and $\varepsilon''(0) < 0$, then this term would contribute to a force toward the smaller electrode (which would be in agreement with experiment).

Alternatively, the term $\frac{1}{2}\nabla[(\varepsilon_{eff} - \varepsilon)E^2]$ may have the wrong sign but may be small. This must be determined experimentally by studying the dielectric properties of air or other gas.

The third term in the force Equation (33) is difficult to evaluate. It may well be negligible, especially compared to the first term (assuming highly nonlinear dielectric response at high fields). Alternatively, if the air behaves as a nearly linear dielectric medium, then $\varepsilon_{\text{eff}} \sim \varepsilon$, and the dielectric constant of a gas is typically proportional to its density, $\varepsilon = \alpha\, \varepsilon_0\, \rho$, where ε_0 is the permittivity of free space, and α is a constant. Using these expressions in Equation (33) for ε yields the force on the capacitor electrodes for the case of a linear dielectric fluid:

$$\left(F_{\text{electrodes}}\right)_{\text{Linear Medium}} = \int_{\Omega} \left\{ -\frac{1}{2} \varepsilon \nabla E^2 - \rho_{\text{ext}} \mathbf{E} \right\} dV. \quad (36)$$

For a linear medium, the first term in Equation (35) contributes to a force pointing in a direction that is opposite to the gradient of the square of the electric field, *i.e.* it points toward the larger electrode (opposite to the experimentally observed force). In order to obtain a net force from Equation (36) that is oriented toward the smaller electrode, the second term in Equation (36) would have to dominate, *i.e.* the net force on the capacitor would be due to external charge effects. The magnitude of the external charges (from battery and surrounding air) on the dielectric fluid must be determined experimentally.

If the space between the capacitor plates is filled with a vacuum instead of dielectric, Equation (33) reduces to a force given by

$$\left(\mathbf{F}_{\text{electrodes}}\right)_{\text{Vacuum}} = -\int_{\Omega} \rho_{\text{ext}} \mathbf{E}\, dV. \quad (37)$$

where $\rho_{\text{ext}} = 0$ for vacuum, leading to zero force on the capacitor.

The thermodynamic theory presented here provides a general expression in Equation (33) for the net force on a capacitor in terms of the macroscopic electric field **E**. This electric field in Equation (33) must be determined by a microscopic calculation, taking into account the ionization of gas between capacitor plates, and details of charge transport.

In summary, at the present time, the relative magnitudes of the fours terms in the force expression given in Equation (33) are unknown. The magnitudes of these terms must be determined by constructing a set of experiments designed to determine the field-dependent dielectric properties of the fluid (given by ε) surrounding the asymmetric capacitor electrodes. These experiments will permit us to verify if the thermodynamic theory presented here can explain the magnitude and sign of the observed force.

6. Summary and Suggested Future Work

We have presented a brief history of the Biefeld-Brown effect: a net force is observed on an asymmetric capacitor when a high voltage bias is applied. The physical mechanism responsible for this effect is unknown. In Section 4, we have presented estimates of the force on the capacitor due to the effect of an ionic wind and due to charge drift between capacitor electrodes. The force due to ionic wind is at least three orders of magnitude too small. The force due to charge drift is plausible, however, the estimates are only scaling estimates, not a microscopic model.

In Section 5, we have presented a detailed thermodynamic theory of the net force on a capacitor that is immersed in a nonlinear dielectric fluid, such as air in a high electric field.

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The main result for the net force on the capacitor is given in Equation (33). The thermodynamic theory requires knowledge of the dielectric properties of the fluid surrounding the capacitor plates. It is not possible to estimate the various contributions to the force until we have detailed knowledge about the high-field dielectric properties of the fluid.

More experimental and theoretical work is needed to gain an understanding of the Biefeld-Brown effect. As discussed, the most pressing question is whether the Biefeld-Brown effect occurs in vacuum. It seems that Brown may have tested the effect in vacuum, but not reported it (Appendix B). More recently, there is some preliminary work that tested the effect in vacuum, and claimed that there is some small effect—smaller than the force observed in air; see the second report cited in Reference 2. Further work must be done to understand the effect in detail. A set of experiments must be performed in vacuum, and at various gas pressures, to determine the force versus voltage and current. A careful study must be made of the force as a function of gas species and gas pressure. In order to test the thermodynamic theory presented here, the dielectric properties of the gas must be carefully measured. Obtaining such data will be a big step toward developing a theoretical explanation of the effect. On the theoretical side, a microscopic model of the capacitor (for a given geometry) must be constructed, taking into account the complex physics of ionization of air (or other gas) in the presence of high electric fields. Only by understanding the Biefeld-Brown effect in detail can its potential for applications be evaluated.

Acknowledgments

Thomas Bahder thanks W.C. McCorkle, Director of Aviation and Missile Command, for the suggestion to look at the physics responsible for the net force on an asymmetric capacitor. The authors want to thank Jean-Louis Naudin (JLN Labs) for his permission to reproduce the letter of Thomas Townsend Brown in Appendix B. Thomas Bahder is grateful for personal correspondence with Jean-Louis Naudin (JLN Labs).

References

1. There are numerous references to asymmetric capacitors, called "lifters" on the internet; see websites: http://jnaudin.free.fr/ (J. Naudin); http://www.soteria.com/brown/ (Information about Thomas Townsend Brown); http://www.tdimension.com/ (Transdimensional Technologies); http://www.jlnlabs.org (J. Naudin) http://tventura.hypermart.net/index.html (American Antigravity)
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Appendix A. Short Patent History Dealing With Asymmetric Capacitors

- Townsend Brown, T. "A Method of and an Apparatus or Machine for Producing Force or Motion," GB Patent 300,311, issued on November 15, 1928[6].
- Townsend Brown, T. "Electrokinetic Apparatus," U.S. Patent 2,949,550, issued on August 16, 1960.
- Bahnson, A. H. Jr. "Electrical Thrust Producing Device," U.S. Patent 2,958,790, issued on November 1, 1960.
- Townsend Brown, T. "Electrokinetic Transducer," U.S. Patent 3,018,394, issued on January 23, 1962.
- Townsend Brown, T. "Electrokinetic Apparatus," U.S. Patent 3,187,206, issued on June 1, 1965.
- Bahnson, A.H. Jr. "Electrical Thrust Producing Device," U.S. Patent 3,227,901, issued on January 4, 1966.
- Cambell, J. W. (NASA). "Apparatus for Generating Thrust Using a Two Dimensional, Asymmetrical Capacitor Module," U.S. Patent 2,002,012,221, issued January 31, 2002.
- Cambell, J. W. (NASA). "Apparatus for Generating Thrust Using a Two Dimensional Asymmetric Capacitor Module," U.S. Patent 6,411,493, issued on June 25, 2002.

Appendix B. Force on Asymmetric Capacitor in Vacuum

Thomas Bahder had email correspondence with Jean-Louis Naudin (JLN Labs),[1] who hosts a website on "Lifters." In this correspondence, Naudin quotes a letter, purportedly signed by T. Townsend Brown, in which Brown discusses the question of whether an asymmetric capacitor has a net force on it in vacuum under high voltage. T. Townsend Brown's letter, as provided by J. Naudin [letter is unedited]:

Dear ....,

You have asked several questions which I shall try to answer. The experiments in vacuum were conducted at "Societe Nationale de Construction Aeronautique" in Paris in 1955-56, in the Bahnson Laboratories, Winston-Salem, North Carolina in 1957-58 and at the "General Electric Space Center" at King of Prussia, Penna, in 1959.

Laboratory notes were made, but these notes were never published and are not available to me now. The results were varied, depending upon the purpose of the experiment. We were aware that the thrust on the electrode structures were caused largely by ambiant ion momentum transfer when the experiments were conducted in air. Many of the tests, therefore, were directed to the exploration of this component of the total thrust. In the case of the G.E. test, cesium ions were seeded into the environment and the additional thrust due to seeding was observed.

In the Paris test miniature saucer type airfoils were operated in a vaccum exceeding 10^{-6}mm Hg. Bursts of thrust (towards the

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positive) were observed every time there was a vaccum spark within the large bell jar. These vacuum sparks represented momentary ionization, principally of the metal ions in the electrode material. The DC potential used ranged from 70kV to 220kV.

Condensers of various types, air dielectric and barium titanate were assembled on a rotary support to eliminate the electrostatic effect of chamber walls and observations were made of the rate of rotation. Intense acceleration was always observed during the vacuum spark (which, incidentally, illuminated the entire interior of the vacuum chamber). Barium Titanate dielectrique always exceeded air dielectric in total thrust. The results which were most significant from the standpoint of the Biefeld-Brown effect was that thrust continued, even when there was no vacuum spark, causing the rotor to accelerate in the negative to positive direction to the point where voltage had to be reduced or the experiment discontinued because of the danger that the rotor would fly apart.

In short, it appears there is strong evidence that Biefeld-Brown effect does exist in the negative to positive direction in a vacuum of at least 10^{-6} Torr. The residual thrust is several orders of magnitude larger than the remaining ambient ionization can account for. Going further in your letter of January 28th, the condenser "Gravitor" as described in my British patent, only showed a loss of weight when vertically oriented so that the negative-to-positive thrust was upward. In other words, the thrust tended to "lift" the gravitor. Maximum thrust observed in 1928 for one 28 gravitor weighing approximately 10 kilograms was 100 kilodynes at 150kV DC. These gravitors were very heavy, many of them made with a molded dielectric of lead monoxide and beeswax and encased in bakelite. None of these units ever "floated" in the air.

There were two methods of testing, either as a pendulum, in which the angle of rise against gravity was measured and charted against the applied voltage, or, as a rotor 4 ft. in diameter, on which four "gravitors" were mounted on the periphery. This 4 ft. wheel was tested in air and also under transformer oil. The total thrust or torque remained virtually the same in both instances, seeming to prove that aero-ionization was not wholly responsible for the thrust observed. Voltage used on the experiments under oil could be increased to about 300kV DC and the thrust appeared to be linear with voltage.

In subsequent years, from 1930 to 1955, critical experiments were performed at the Naval Research Laboratory, Washington, DC.; the Randall-Morgan Laboratory of Physics, University of Penna., Philadelphia; at a field station in Zanesvill, Ohio, and two field stations in Southern California, of the torque was measured continuously day and night for many years. Large magnitude variations were consistently observed under carefully controlled conditions of constant voltage, temperature, under oil, in magnetic and electrostatic shields, not only underground but at various elevations. These variations, recorded automatically on tape, were statistically processed and several significant facts were revealed.

There were pronounced correlations with mean solar time, sideral time and lunar hour angle. This seemed to prove beyond a doubt that the thrust of "gravitors" varied with time in a way that related to solar and lunar tides and sideral correlation of unknown origin. These automatic records, acquired in so many different locations over such a long period of time, appear to indicate that the electrogravitic coupling is subject to an extraterrestrial factor, possibly related to the universal gravitational potential or some other (as yet) unidentified cosmic variable. In response to additional questions, a reply of T.T. Brown, dated April, 1973, stated: "The apparatus which lifted itself and floated in the air, which was described by Mr Kitselman, was not a massive dielectric as described in the English patent.Mr Kitselman witnessed an experiment utilising a 15" circular, dome-shaped aluminum electrode, wired and energized as in the attached sketch. When the high voltage was applied, this device, although tethered by wires from the high voltage equipment, did rise in the air, lifting not only its own weight but also a small balance weight which was attached to it on the underside. It is true that this apparatus would exert a force upward of 110% of its weight."

The above experiment was an improvement on the experiment performed in Paris in 1955 and 1956 on disc air foils. The Paris experiments were the same as those shown to Admiral Radford in Pearl Harbor in 1950.

These experiments were explained by scientific community as due entirely to "ion-momentum transfer", or "electric wind." It was predicted categorically by many "would-be" authorities that such an apparatus would not operate in vaccum. The Navy rejected the research proposal (for further research) for this reason. The experiments performed in Paris several years later, proved that ion wind was not entirely responsible for the observed motion and proved quite conclusively that the apparatus would indeed operate in high vacuum.

Later these effects were confirmed in a laboratory at Winston-Salem, N.C., especially constructed for this purpose. Again continuous force was observed when the ionization in the 29 medium surrounding the apparatus was virtually nil. In reviewing my letter of April 5th, I notice, in the drawing which I attached, that I specified the power supply to be 50kV. Actually, I should have indicated that it was 50 to 250kV DC for the reason that the experiments were conducted throughout that entire range.

The higher the voltage, the greater was the force observed. It appeared that, in these rough tests, that the increase in force was approximately linear with voltage. In vaccum the same test was carried on with a canopy electrode approximately 6" in diameter, with substantial force being displayed at 150 kV DC. I have a short trip of movie film showing this motion within the vacuum chamber as the potential is applied.

Kindest personal regards,
Sincerely,
T. Townsend Brown

About the Authors

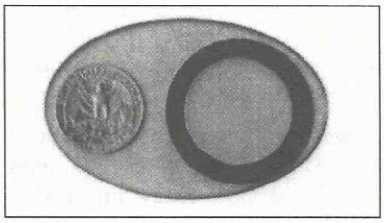
Dr. Bahder received a Ph.D. in theoretical physics from Rutgers University in 1984, and has been working at the Army Research Laboratory in Adelphi, Maryland, for the past eighteen years. Dr. Bahder has worked on a number of areas, including electron many body physics, optical and electrical properties of semiconductors and quantum wells, relativistic effects in the GPS system, and relativistic time and position determination. More recently, Dr. Bahder is pursuing cold atom technology for sensor applications.

Dr. Fazi has been a researcher at the Army Research Labs in Adelphi, Maryland for the past thirty-two years, and holds a Ph.D. in electrical engineering. Presently he is the program manager for Frequency Control and has been involved in several Army rf and microwave research programs. He has about fifty rf and solid state research publications. Dr. Fazi is an adjunct faculty member at the Johns Hopkins University, where he teaches a microwave CAD lab involving rf front-end designs. He is a life member of the Amateur Radio Relay League and is an avid microwave moon-bouncer.

*U.S. Army Research Laboratory, 2800 Powder Mill Road, Adelphi, MD 20783-1197
E-Mail: bahder@arl.army.mil

New Power Technology Claims to Nearly Double Available Energy in Automobiles

A press release from Power Chips plc.



Power Chip prototype (shown with a U.S. quarter for size comparison).

A new power generation technology could sharply increase the ability of a car's engine to convert fuel into useful power. By capturing waste heat energy and converting it into electricity, Power Chips plc, a majority owned subsidiary of Borealis Exploration Limited (BOREF), says it could increase an automobile engine's effective power output by 75%, significantly improving vehicle performance, efficiency, and design flexibility.

Less than 15% of the energy in a gallon of gasoline reaches the wheels of a typical car; most of the rest is wasted as heat. Power Chips are designed to capture this wasted energy and convert it into electricity that can be used to power ancillary systems such as air-conditioning or entertainment.

By eliminating these secondary loads from the car's engine, all of the mechanical output can be directed into the drivetrain. This could allow auto manufacturers to design lighter, more fuel-efficient engines without sacrificing horsepower and torque. In new hybrid vehicles, the increased power could translate directly into improved acceleration and range for electric motors.

Power Chips are wafer-thin, fingernail-sized diodes that use quantum mechanical thermotunneling to generate electricity from heat. They are expected to have a wide range of applications and to produce electrical power more efficiently and less expensively than any existing technology.

By eliminating the drain on an internal combustion engine required to produce electricity, the engine's full power can be directed to the driveshaft. Automakers may thus be able to achieve the same horsepower and torque output with smaller, lighter, and more fuel-economical engines. And by using Power Chips to generate electricity, automotive manufacturers will be able to eliminate alternators and belts and obtain greater design flexibility.

This automotive application of Power Chips is described in a paper, "Automotive Waste Heat Recovery Using Power Chips," which was presented by Power Chips' Dr. Brian Von Herzen in September 2002 at the Global Powertrain Congress in Ann Arbor, Michigan.

Since most of the energy consumed by an internal combustion engine is wasted, capturing much of that wasted energy can provide a large increase in energy efficiency. A typical engine producing 100 kilowatts of driveshaft power, for example, expels another 68 kilowatts of heat energy through the radiator and 136 kilowatts through the exhaust. The paper says that a panel of Power Chips against the radiator, if they reach their projected 70% of maximum possible efficiency, should generate 8.7 kilowatts, while Power Chips wrapped around the exhaust pipe could produce as much as 68 kilowatts.

"If Power Chips realize their potential," the paper concludes, "they will be able to replace the alternator, power all auxiliary loads electrically (including climate control), and add significant shaft power to an automobile with an electric-assist drivetrain—perhaps a total electrical power which is fully 75% of the shaft power of the primary engine. The devices are designed to achieve this goal for less than $20 per kilowatt capacity, which is highly competitive with all alternator systems, but with no additional fuel cost for the energy generated."

The Power Chip is one of the first transformative technologies to emerge from the nanotechnology revolution. Power Chips are discs comprising two electrodes separated by a gap of less than 20 nanometers, through which the hottest (most energetic) electrons tunnel to create an electrical current. Power Chips are silent, nonpolluting, solid-state devices that are scalable as arrays to meet any size power load. They can generate electricity from heat produced by any primary energy source, including geothermal, coal, gasoline, natural gas, methane, and hydrogen.

They are projected to operate at 70% of the maximum theoretical efficiency for energy conversion, even when converting low-grade waste heat. The only other technology capable of converting such heat directly to electrical output is thermoelectric (Peltier) devices, but the efficiency of production thermoelectric systems is only 5-8%.

Power Chips were invented and are being developed and licensed by Power Chips plc, a majority-owned subsidiary of Borealis Exploration Limited (BOREF). Both companies are incorporated in Gibraltar. Borealis' business is reinventing the core technologies used by basic industries, including electrical power generation, cooling and thermal management, electric motors, and steel production.

Power Chips are protected by an extensive patent portfolio covering general theory and specific techniques for quantum thermotunneling and thermal energy conversion. More details are available on the Power Chips plc website: http://www.powerchips.gi, including the full text of issued patents and photographs of prototype Power Chips. □□□

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ECLECTIC OBSERVER

Compiled by Eugene Mallove

The Energy Freedom Resolution:
A Proposed Congressional Resolution

Over a decade of trying to enlighten politicians and government administrators about the realities of truly *new* energy (*not* solar panels and windmills) has lead to very low expectations that any beneficial actions for new energy will come from officials in Washington. Still, it is good to keep the political kettle stirred, so I offer this proposal for letter-writing and elbow-rubbing campaigns by the more energetic activists in our readership, who may wish to carry the ball. The Energy Freedom Resolution, which if adopted would not entail a single penny of new Federal funding, may have only a "snowball's chance in hell," but why not give it a try? And please *do* report to this Editor any useful—or unhelpful—responses that may emerge:

The Energy Freedom Resolution

A proposed *resolution* (not a *law*) for the U.S. Senate and/or the U.S. House of Representatives. Be it resolved that: (1) That the Department of Energy is respectfully urged to conduct, in conjunction with the National Academy of Sciences, a review of the evidence that has mounted since 1989 for excess heat and nuclear effects, which has been published by scientists within what has become widely known as the field of cold fusion/low-energy nuclear reactions. Since the ERAB (Energy Research Advisory Board) Cold Fusion Panel rendered a negative assessment during only six months of active review (DOE/S-0073), it is essential to have a fresh look at the evidence.

And be it further resolved that: (2) The Department of Energy should, within its present budget, establish an Office of New Energy Investigations (ONEI) for the following purpose: ONEI shall thoroughly and fairly test operating devices brought to its attention by scientists and inventors who claim to be generating "anomalous energy," that is, previously unexplained energy. Test reports reaching positive or negative conclusions about claimed anomalous (unexplained) energy devices are to be made public along with details of the testing methodology by which the conclusions were reached. Moreover, the devices brought to the attention of ONEI will be tested without regard to unscientific prejudice that such performance is "theoretically impossible." It is the spirit of this resolution that science has most certainly not come to an end and that all efforts need to be made to ensure that these claims of new energy are fairly assessed.

U.S. Presidential Campaign Stirs Energy Debate

Here we go again. . .It is long before the very important New Hampshire primary in February or March 2004 for the U.S. Presidential election of November 2004. Already a number of Democratic Party candidates are at each other's throats as they vie for the right to challenge Republican President George W. Bush in 2004. It is noteworthy that a number of them appear to be focussing on energy policy as prominent parts of their campaigns. Our necessarily non-partisan reporting will from time to time take note of these positions:

• A campaign flier from U.S. Senator John Kerry (D-MA) states: "Make America Energy Independent: John Kerry has led the fight to make our vehicles more efficient and to encourage the use of new clean energy sources like solar power, ethanol, biomass and hybrid fuel cells. He will institute a program to increase our energy independence—for our national security, our economic security, and our environment."

• The campaign website of U.S. Senator Joseph Lieberman (D-CT) states: "(May 7, 2003) WASHINGTON, D.C. In the first of a series of major policy initiatives, Joe Lieberman today unveiled a 'Declaration of Energy Independence' that would reduce our dependence on foreign oil by nearly two-thirds within 10 years and help America kick its foreign oil habit completely within 20 years. Lieberman's plan would make America energy independent by tapping new technologies, adopting flexible market-based systems, and protecting our environment."

Question: Will *any* of the Presidential candidates open their eyes and inject truly *new* energy into the 2004 election debate? Would any of these candidates endorse the Energy Freedom Resolution, as an example? If the past is any guide, this will not happen.

U.S. Supreme Court Denies Inventor's Petition
Constitutional Rights Vaporized by the Whim of the Many

On June 9, a clerk of the U.S. Supreme Court rejected cold fusion inventor Dr. Mitchell R. Swartz's *pro se* April 17, 2003 "Petition for a Writ of Certiorari," which could have overturned a flawed decision by the United States Court of Appeals for the Federal Circuit (rendered November 8, 2002) in the matter of one of Dr. Swartz's inventions, and more importantly, protected American inventors and strengthened the Constitution. Dr. Swartz's invention is a multiring calorimeter (heat-measuring instrument) and method used to examine and compare heat-generating metal samples with full thermal controls (see *Infinite Energy* #20). The invention measures the heat which the samples produce when electricity is driven through them. Some of the heat is generated from the loading of hydrogen (a fuel) into palladium (a metal which absorbs hydrogen in the same way that a sponge fills with water). The invention accurately characterizes the "activity" of the sample and of other metals and of controls, where activity is defined as the ratio of the output heat power given off by the sample compared to the electrical input power delivered. Thus, the invention does not require cold fusion excess heat producing methodologies *per se*. Nonetheless, the opposing forces from the U.S. Patent Office, as if motivated by intense animosity toward Dr. Swartz and his many years of patent applications within the cold fusion domain, persisted throughout the entire process of this litigation to claim that the invention involved "cold fusion." This is a concept that the

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opposition from the USPTO did not cease to ridicule through the years that this matter had been in process. The U.S. Patent Office under the Commissioner for Patents Godici has systematically and wrongly refused to issue many cold fusion and alternative energy patent applications—even those for monitoring (or measuring) energy, such as Dr. Swartz's invention. Dr. Swartz told *Infinite Energy*, "Godici's Patent Office has systematically made the claim, even with the United States at war against terror, that energy measurement, energy generation, and energy storage have no utility—that is, they are not useful. This must have been done tongue-in-cheek because the Patent Office has issued patents for inventions used to 'predict' lottery numbers based on astrology [*e.g.* Patent 6,371,482] claiming that they have 'operability' and 'utility' while the energy measurement inventions do not."

The case had reached the U.S. Court of Appeals in the first place after an unsatisfactory outcome against Swartz at the Board of Patent Appeals and Interferences earlier (filed 1998). Swartz's accurate and compelling arguments in his *pro se* filing at the U.S. Supreme Court, formally against Nicholas P. Godici, Commissioner for Patents, is to be contrasted to the reckless and politicized arguments by the USPTO representatives that have dogged Dr. Swartz's appeal process in the matter of this invention application. Among numerous proverbial bombs inappropriately thrown against Swartz were explicit references to the now provably flawed calorimetric results of anti-cold fusion groups at MIT and at Caltech. Despite evidence submitted by Dr. Swartz demonstrating their errors, the evidence was ignored. The Patent Office also relied upon false statements about Dr. Swartz's application claiming that "temperature" and "voltage" were not mentioned when, in fact, they were. Also, statements taken clearly *out of context* from *Infinite Energy* and other sources were devilishly employed to oppose Swartz's arguments and those of many *amicus curae*, including this Editor, who offered statements in support of the utility of the invention.

The battle is not over. Dr. Swartz has submitted a Petition to the Court to reconsider the entire matter. The question he poses is: What is the constitutional obligation of the Supreme Court to enforce the protections offered by the Constitution (such as for a citizen to his/her invention) when near-"unanimous" opinion appears to trump hard evidence (as the hot fusion community has done to the copious proofs of cold fusion based on observed excess heat, *de novo* helium production, and isotope changes)? This issue is important because patents should be based on evidence, consistent with scientific standards of review.

From this observer's perspective, it will eventually take a Congressional investigation to abolish the anti-scientific, anti-cold fusion hysteria at the USPTO. How can *Infinite Energy* readers help? Interested readers can inform the Supreme Court and tell them that the American people deserve the fruits produced by all American inventors, and can inform the Commissioner for Patents that he is wrong. [Commissioner for Patents, Nicholas Godici, Phone: 703-305-8800; Fax: 703-305-8825; E-mail: Nicholas.Godici@USPTO.gov]

"Memory of Water" Preserved in Heavy Water Ice?

New scientific evidence, about to be published in mainstream physics journal *Physica A* by Swiss chemist Louis Rey, is said to lend support to the "memory of water" concept that may form the basis for homeopathic medicine. This, according to a news article by Lionel Milgrom in *New Scientist* (June 14, 2003, p. 22). Rey used a technique in which D_2O ice chilled to below 90°K is subjected to ionizing radiation. Upon being warmed up, light from "thermoluminescence" is emitted by the sample and a plot of its intensity versus temperature is mapped out. Two peaks, at 120°K and 170°K, were observed in this pure sample. These reflect the pattern of hydrogen bonding within the ice.

To test whether "homeopathic dilutions" might affect this pattern, Rey prepared dilutions in heavy water—according to the homeopathic protocol of violent shaking between successive 10% dilutions—of lithium chloride (LiCl) and then sodium chloride (NaCl). These dilutions were such that it was highly improbable that *any* ions of the solute had remained in the solutions, so conventional physics and chemistry would suggest that only pure heavy water remained. The treated, but supposedly pure heavy water, was then frozen and subjected to the same radiation and heating up thermoluminescence observations. To the great surprise of Rey, who intended to challenge the memory of water concept with these experiments, instead of the curve observed with absolutely virgin heavy water, the light from the homeopathically treated samples gave signatures as though the LiCl or the NaCl were still present! The results suggest that the pattern of hydrogen bonding in the ionic solution is somehow preserved by the "memory of water" effect. These tests are reported to be highly repeatable.

This work would seem to add another completely unexpected channel of validation to the work pioneered by Jacques Benveniste and his colleagues in France, which was published in *Nature* in 1988, and subsequently viciously trashed by *Nature's* then editor John Maddox, magician James Rand and others—even though that work had been successfully reproduced by others. See our review of the book by Michel Schiff on the memory of water controversy, in *Infinite Energy's* "Water Issue" (#33, September/October 2000). This remarkable emerging physics may well have relevance to other anomalous water phenomena, such as cold fusion.

DOE Cold Fusion Panel's John Huizenga Admits Continuing Role to Squash Cold Fusion

At a very chance meeting at a social gathering on the east coast, an active member of the cold fusion research community elicited an amazing admission by Dr. John Huizenga. The now formally retired Professor Huizenga headed the DOE's 1989 rush-to-judgment Cold Fusion Panel and later wrote a very negative book on the subject, *Cold Fusion: The Scientific Fiasco of the Century*. Huizenga did not at first recognize the cold fusion researcher, who had merely inquired if this was *the* John Huizenga of anti-cold fusion fame. But in reflexively boasting about his infamous book, Huizenga was overheard reiterating his contempt for the 1989 work of Drs. Fleischmann and Pons. He gleefully reported that he had recently returned from a visit to DOE in Washington, D.C. to specifically—we are paraphrasing here—"prevent cold fusion from rising again." Apparently, Huizenga's "retirement job" is to continue fighting cold fusion and hype his flawed book. It is noteworthy that there may be some possible "life" for cold fusion within the bowels of DOE, as evidenced by Huizenga's admission. Perhaps some minor faction of the troops within DOE are seeing the light! Maybe we'll discover them *incognito* at ICCF10. . .

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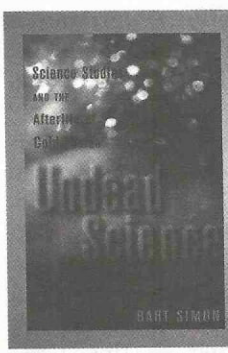
Book Reviews



Undead Science: Science Studies and the Afterlife of Cold Fusion

by Bart Simon
ISBN 0-8135-3154-3
$22.00 Paperback, 252 pp.
Rutgers University Press, 2002

Review by Eugene F. Mallove

Unlike the handful of books that dissect the cold fusion controversy from a detailed historical or scientific perspective[1-5]—and which conclude whether cold fusion/LENR investigations represent evidence of a major new physical reality or are merely "pathological science"—sociologist of science Bart Simon's *Undead Science* focuses primarily on the *sociology* of the cold fusion controversy. In that sense the book represents a kind of mid-ground between the advocates and antagonists in the cold fusion war. Some cold fusion proponents have welcomed this book as a good opening to the Science and Technology Studies (STS) academic community, and perhaps to a wider audience of scientists and laypersons. I think they have a very wrong idea. This book will gain few friends for cold fusion research. The book is simply a waste of time. It is junk sociology based on a poor understanding of science and its controversies.

Undead Science may cause a stir within the STS community, because most of these sociology of science folks appear to be blissfully unaware that there is a large body of cross-correlated experimental evidence that confirms the reality of large energy magnitude excess heat and nuclear effects in novel hydrogen systems. One might excuse this, since *some* of the sociologists of science I have encountered—including Simon, who extensively interviewed me and others for his book—evidently lack the scientific skills to begin to grasp this prospect. Their fall-back position is simply to study the dynamics of the controversy. Other science sociologists, such as the late Dr. Marcello Truzzi, had a clear understanding of the dynamics of scientific controversies in the context of acceptance of an approachable ultimate Truth about Nature. That is why Truzzi became an avid observer of the cold fusion war and a friend of *Infinite Energy*.

However, this particular book by sociologist Simon adds nothing but confusion to the understanding of what the process of science *is* about—or should be about. Nowhere in the book do we find a loud and clear statement that there is, indeed, *one physical reality* out there—whether or not communities of human beings are able to agree on what that reality is. This is a very important omission. It is the book's central flaw, leaving it without a legitimate foundation. In his concluding chapter Simon writes, ". . .the central guiding assumption of this book has been the inherent interpretive flexibility of experimental data and the *a priori* undecidability of the fact of the matter in the case of cold fusion." Given that untenable remark, Simon still has no trouble throughout claiming that "closure" in the cold fusion controversy occurred in 1990! What then is the meaning of "interpretive flexibility" of experimental data—especially that gathered *after* 1990?

What we find instead of assessment of the relative significance or merit of *data*—pro and con—is Simon's extended metaphorical discussion of what characterizes "undead science" in the instance of cold fusion. Some of his chapter titles give the general idea of the ghostly imagery that pervades the book: Chapter 4: The Pallor of Death; Chapter 5: The Afterlife of Cold Fusion; Chapter 6: Tales from the Crypt; and Chapter 7: A Hauntology for the Technoscientific Afterlife. Simon flaunts such imagery throughout, as though we should be impressed by this swinging trapeze artist's linguistic gymnastics.

Perhaps others, taking up Simon's metaphor, will later deem the "memory of water" controversy as undead science, or maybe challenges to Einsteinian relativity will be termed "undead science," rather than attempts to do proper pioneering science or careful scientific criticism. This is simply to suggest the preposterous nature of Simon's viewpoint, in which essentially no effort is made to assess where lies the preponderance of evidence. Is cold fusion research new science or the malformed specter of the critic's invention, "pathological" science? It is as though a jury, charged with deciding the fate of an accused murderer based on mountains of evidence painstakingly collected over a decade by the prosecution, and on the other hand a small hill of glaringly defective defense counter-evidence gathered hastily in six months, could not bring itself to render a judgment. What else is to be expected from an author who writes on page one with zero qualification, "The controversy over cold fusion had basically ended by 1990. . ."?

Simon writes elsewhere in a passage particularly revealing of his analytical confusion, "The force of my argument depends on my being able to demonstrate that closure has occurred in the case of cold fusion. . .Without a notion of closure, cold fusion is simply alive, and much of what has occurred in the case will not make any sense." What?

Apart from these evident flaws, a very annoying—and unnecessary—aspect of *Undead Science* is Simon's quotation from anonymous sources. One supposes that by this artifice Simon intended to milk frank commentary out of reluctant critics. A 1994 e-mail interview by Simon with an unidentified chemist begins thus: "The problem with cold fusion as a legitimate research goal is that so much of the phenomenological basis for the effect has been shown to be either mistaken, possibly fraudulent, or simply not reproducible in the hands of established authorities, that little or nothing remains of the original hypothesis." Who is this "chemist" who in 1994 speaks glibly of fraud within cold fusion and who believes that "established authorities" can legitimately peer review frontier science? One would dearly like to know. He/she is one of the first anonymous creatures—let us call them "ghosts," following Simon's metaphor—interviewed in *Undead Science*.

Fourteen years into the cold fusion war, I am no longer particularly put off by misdirected tracts such as *Undead Science*. It is just more background noise as science progresses, and it is not very attractive noise at that. At least, let us

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have a bit of good background music! There are many borderline unreadable passages, such as this gem of academic flourishing and puffery from page 200: "Truth does not therefore reside in the procedures of transcendental justification of the kind strived for by some rationalist philosophers, but is rather a consequence of the local achievements of actors in defining the boundaries of what counts as legitimate knowledge and who counts as a legitimate knower in a given cultural context. Further, that such achievements often transcend the local conditions of their origin is a matter of their contingent extension in time and space by specific actors, and not of any inherent property of the achievements themselves."

This inept attempt at understanding the sociology of the cold fusion controversy will, I believe, mercifully go largely unnoticed. At least blatantly negative books such as Close's, Huizenga's, or Taubes' clearly reveal the borderline criminal intent of cold fusion's opponents, a transparent intent which Bart Simon is too dense to properly assess. In that sense those books stand as very valuable historical self-indictments of cold fusion's antagonists. Simon's book is not evil; it is simply irreducibly stupid. I am not particularly upset when I read, after one of my *Infinite Energy* editorials is quoted by Simon (elsewhere in the book I find myself *anonymously* quoted!): "Mallove and *Infinite Energy* are also ghostly figures. His editorial can be read at the same time as both the idiosyncratic ranting of a crazed lunatic and an important framing narrative for the organization of cold fusion research after the closure of the controversy." After all, anyone who asserts that there has been some kind of "closure" to the cold fusion controversy neither understands science nor its process. He cannot judge the "rantings" of anyone.

Simon's barely concealed true feelings about cold fusion occasionally slip out, such as on page 219 as he is winding down prose that has qualified for his doctoral dissertation: "Finally, it is important to point out that *since CF research was for a brief time a form of legitimate science* (reviewer's italics), so it remains tied or bound to the norms and expectations of legitimate science. Like a spirit that is bound to the place where it died, CF researchers are tied to the normal expectations of science." Need we cite any more evidence of how wrong minded and disingenuous Simon's thesis is? Simon's book, above all, is a very poor advertisement for so-called "STS" departments. Are academics really paid to write and—heaven forfend!—*teach* such confused gibberish? Simon ends with an apt summation of his book: "By now it should be clear that the argument of this book is an extended ghost story." If one wants to find a *real* ghost story, may I suggest a visit to the horror and fantasy section of a bookstore, not the science section, where unfortunately Simon's *Undead Science* is likely to be found for a time—until it dies its inevitable natural death.

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How to Make Intellectual Property Available to the Greatest Number of People

Michel Dubois*

This paper was first presented at a conference at the University of Toronto in Canada on May 31, 2002, and is reprinted with permission of the author. Other documents by the author can be downloaded at www.univention.ca.

Editor's Introduction:

For many years the New Energy field the world over has wrestled with the legal, administrative, and financial problems of the patent process. It was therefore with great interest that we first read Michel Dubois' unusual perspective on the nature of patents. We hope that by publishing his comments and proposals for alternative methods, it will stimulate useful reconsideration of intellectual property protection in our field. —*Eugene Mallove*

Prologue

Conceived at the end of the eighteenth century, *patent* is an undemocratic title that is totally unsuited for the inventor's social condition. Indeed, it provides the applicant with a *temporary* monopoly of commercialization that is delivered by sovereignty of State. Such a privilege *implies costs that the inventor cannot afford to pay, as well as the loss of secrecy of his technique and the disclosure of his commercial strategy to competitors* (*i.e.* passive and active technological vigil).

Conceived at the end of the eighteenth century, *Copyright* is a democratic instrument that provides an author *free of charge* with the exclusive right to produce and reproduce his Work of the Mind. Such a right is valid for the author's entire lifetime plus fifty to seventy years after his death. It is granted free of charge for two basic reasons: on the one hand, it results from the talent required to create the author's work; on the other hand, it results from the universal, permanent, and *unquestionable property* of such a work, *which is valid even without disclosure* (*i.e.,* maintaining secrecy).

For more than two centuries, the use of patent (or any other title of monopolistic commercialization) has distorted the notion of *protection*. Entrenching themselves behind tradition, expert counsels falsely recommend patent as a means of protecting inventions. Such mental conditioning has had paradoxical effects. Indeed, even though one is well aware that the words "protection" and "protect" are misleading, both professionals and laymen readily apply such words in and out of context. It truly is a case of the blind leading the blind. To make matters worse, the Canadian Intellectual Property Office (CIPO), like institutes in other countries, provides explanations that are clearly aimed at misinforming the reader. In its *Guide to Patents* (ISBN 0-662 84233-2), page 12, the CIPO comments on the actual meaning of the word protection. Let us examine this specific document:

> What does "protection" mean? Patent Infringement. Patent infringement would occur if someone made, used or sold your patented door lock without your permission in a country that has granted you patent, during the term of the patent. If you believe your patent has been infringed, you may sue for damages in the appropriate court. The defendant may argue that infringement did not occur, or may *attack the validity of your patent*. The court will determine who is right, basing its decision largely on the language of the claims. If what the defendant is doing is not within the wording of any of the claims of your patent, *or if the patent is declared to be invalid for any reason*, there is no infringement. [emphasis added]

So much for patent's so-called protection! In reality, a definition of patent infringement as a legal recourse would have been simpler and more useful to the reader. One fails to comprehend how the notion of protection can be applied to such a recourse. Unless jeopardizing one's monopolistic rights is one of patent's specific forms of protection! One fact remains clear: *without money, there is no protection*. Doubtless, the lawmaker provided this nebulous explanation in an effort to confuse the reader. Thus everyone (the patent agent as well as the public) construes the words protection and protect according to a stereotyped definition that contradicts logic.

Extreme care is needed when dealing with problems concerning Intellectual Property. One should never lose sight of commercial consequences. An invention that is ahead of its time inevitably challenges traditional values; strong interests are at stake, often concerning lobbies. This increases the danger of being attacked, and the idea of protection therefore becomes illusory.

If, upon its creation (1791), patent had been clearly presented to the public as an instrument specifically intended for industrialists, and not as a means of protecting impecunious inventors (*i.e.,* as a commercial title and not as a property deeds), chances are that, for the last two centuries, a higher sense of equity would have prevailed in business and society.

One can therefore better understand the reasons why, throughout this conference, we shall do our best to avoid the words protection and protect unless they are used in their literal sense (*i.e.,* to shelter). Otherwise,these words will soon lead us to contradictory conclusions. For example, given the *mandatory* publication of patents, it is difficult to understand how can one protect (*i.e.,* shelter) an invention by exposing it. The dictionary only serves to confirm this potential dilemma; the antonym of the verb to protect is "to expose." By dismissing these two amphibolies [a phrase, discourse, or proposition susceptible to two interpretations]

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from the present discussion, we shall surely notice that our vocabulary is rich enough to accurately express our thoughts.

1. Industrialization and Inventors: A Financial Imbalance

The advent of industrialization, more than two centuries ago, resulted in new legal procedures specifically adapted to the interests of the industrial world. Such procedures favored the *commercialization* of the invention at the expense of its author's *initial creation*. Through such legal provisions, invention was defined as the mere *finding* of a technical or technological methodology, and was denied any creative attribute. Given this predicament, the inventor never had the appropriate means, until the present, to prove intellectual property with regards to his creation. This also explains why the traditional business plan is specifically conceived as an *industrial priority* for the entrepreneur. As for the inventor, he needs a business forecast that suits his social condition. Such a document must allow him to attract industrialists who are interested in assuming the costs of commercialization through equitable contracts of license or assignment. A basic feature is that it reflects the interaction of any number of specialities. We shall come back to this subject in the introduction to the International Consortium Business Forecast (ICBF), which is intrinsic to the Intellectual Passport C.B. (see Exhibit A for full definition).

The age-old confusion created by the inadequate use of patent has led to immeasurable losses in business opportunities. The international market of intellectual property is presently underdeveloped (1% of concepts, whether patentable or unpatentable, are patented internationally, namely 47,291 out of 4,730,000 concepts—15% patented nationally—according to a 1996 analysis by the World Intellectual Property Organization, WIPO-Geneva). There is no doubt about the magnitude of the new market opened by the Intellectual Passport C.B.: statistics gathered worldwide prove that it is one hundred times greater than the amount of patents registered each year internationally.

Experience has shown that patent in most cases does not serve the legitimate interests of the author of an invention. Moreover, the holder must extend such a title in every country where the invention can be commercially exploited. Contrarily to the exclusive ownership resulting in copyright, considerable financial means are required to extend one's monopoly internationally, let alone to defend it in courts of law.

Not only is the abusive use of temporary monopolistic titles detrimental to the exclusive property inherent in creation; by reducing access to Intellectual Property, keeping it at its bare minimum, it also increases the gap between rich and poor. Thus the present system of patent is less and less capable of fulfilling the actual potential of one of the noblest markets, if not the most vital for civilization, namely, the market for brain power; mankind's raw material, an inexhaustible source that stimulates the creation of wealth and is essential to mankind's evolution. By making Intellectual Property accessible to each person, human creativity will at last be liberated from material restraints, thus enabling it to act as a stimulus to the constantly emerging innovations that ensure scientific, technical, and technological progress, whether in the field of industry, services, or art.

In short, instead of granting the inventor his due (*i.e.*, a title that unquestionably establishes the author of the invention, along with the associated rights), patent (or other titles) provides the *presumed* author of an invention with a commercial monopoly, which only an industrialist with international means can afford to support. Conversely, copyright results from the recognition of the author as a cre-

Exhibit A. Intellectual Passport C.B. (IPCB)

The Intellectual Passport C.B. is a literary and artistic work with a commercial and social purpose. As a rule, it remains unpublished. In order to create such a work, one must use an original, exhaustive, and universal guide book called "Conventional File I.B."; this operating code serves to *identify* the author of the work and add *business* value to the related commercial strategy. When using this guide book, practitioners must follow the natural and axiomatic order in which the three dynamic virtues that have always activated mankind's progress occur sequentially: creation—invention—innovation. This is the order in which the author first conceives his new idea in its virtual form, from the initial thought until it has been put into concrete form onto a physical medium, *i.e.* creation (Work of the Mind, inalienable property which the author owns definitively). This initial mental process leads to invention (finding a previously unknown method or system), which results from creation. Invention in turns leads to the next phase, *i.e.* innovation (commercializing the innovative product obtained by applying the original method or system resulting from the initial work). Such a sequential order has been ignored for more than 200 years. Given the basic, unquestionable origin and the inalienable nature of the Work of the Mind, the use of this equitable guide book helps restore moral right to its natural place, namely the first one. A universal certificate of anteriority, the Intellectual Passport C.B. is the "personal property" that supports secrecy and can be used to invalidate a subsequent temporary "monopolistic title" of commercialization (patent or other), in any Nation that adhered to one of the two international conventions on copyright or any Nation that adhered to the U.N.'s Charter. This work also provides its author with a negotiation tool, since it includes the following intrinsic elements: "a set of ownership and rights" that belong to him; a triennial business forecast that reflects various specialized activities: the ICBF; finally, its related original system of contractual distribution of commercial rights. This set of texts, this business forecast, and this system are open and progressive; one can implement them simultaneously, independently from one another or one after the other. The Intellectual Passport C.B. stimulates business growth worldwide. An original strategic service that facilitates access to Intellectual Property, it serve both private and public interests and promotes market penetration at a global level. By offering the industrialist the possibility of registering exclusive patent rights, this new product fosters mutual trust between the creator (armed with this work) and the industrialists/entrepreneurs. This didactic instrument is destined to act as a stimulus to constantly emerging innovations which ensure scientific, technical, and technological progress, whether in the field of industry, services, or art.

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ator (original idea), thereby establishing his unquestionable intellectual paternity. Copyright, which results sequentially from the universal, inalienable, and permanent ownership of a literary and artistic work, is strictly concerned with the author's expression of his creative idea in such a work.

In order to use copyright in a legal, original, and innovative way, let us first examine the law governing Intellectual Property.

2. Anteriority: The Principle Underlying Intellectual Property

Much like the law of gravity and parental filiation, *the international rules governing Intellectual Property are based on the principle of anteriority*; namely, the order in which things occur and develop: anteriority → actuality → posterity. This principle constitutes the very heart of intellectual property. For example, the inventor who wants to obtain a patent must first of all attempt to prove his anteriority. This principle traces the growth of an invention from its origin until it reaches the stage where it becomes an end product. Metaphorically, it represents the genealogy of an invention (Δ).

Based on the legal preponderance of anteriority as the primal cause of evolution and progress (a principle followed by every legal system worldwide), this sequential order ensures fair practice in the realm of authors. For example, it is illegal for a third party to copy, without the author's consent, all or part of the latter's work for commercial purposes. As a result of such an order, the American notion of copyright © represents one of the most efficient and dissuasive means of prosecuting fraudulent copying (plagiarism, unfair competition, or unwarranted gain through deceit).

It is by following the sequential order of Nature (Δ) that mankind has imposed itself as master of the material world:

1: Create (bringing into existence)

2: Invent (finding a method)

3: Innovate (introducing into the market)

Namely: 1: Creation* → 2: Invention* → 3: Innovation*

In every country governed by Intellectual Property law, any proof of anteriority can be used to challenge a patent (or any other title of monopolistic commercialization) subsequently registered by a third party. This confirmed by Article 34.1 (1) of the Canadian Patent Act:

> Any person may file with the Commissioner prior art, consisting of patents, applications for patents open for public inspection and printed publications, that the person believes has a bearing on the patentability of any claim in an application for a patent.

3. Index of Recognized Anteriorities

There are three kinds of recognized anteriorities: A) those that are disclosed in the index of Intellectual Property; B) those that are not indexed but are valid since they are commercialized or are inherent in commercial rights that have not yet been disclosed; and C) those that are related to copyright.

A) *Indexed anteriorities*: One can find such anteriorities by making a preliminary search in the catalogue of Intellectual Property institutes or offices. Such a search takes little time (a few weeks) and is affordable (approximately $1,000). However, patents are disclosed only eighteen months after the date of application. Consequently, this preliminary search cannot provide legal knowledge of anteriorities with regards to registrations made during the eighteen months prior to the search for anteriorities (these are the most recent, hence the most important anteriorities).

B) *Anteriorities that are not indexed*:

—First category: This category includes applications for titles of monopolistic commercialization (patent, design, or other) registered in Intellectual Property institutes or offices during the months prior to the search for anteriorities. As long as they are not published, there is no legal means of finding such anteriorities.

—Second category: This is the largest category (90% of commercializable ideas and 60% of patentable inventions); it includes every type of innovation that is commercialized worldwide, ranging from the local workshop or boutique to multinationals: Bic and Zodiac are perfect examples of the latter kind of enterprises. Needless to say, this category comprises many inventions: those that are commercialized under the seal of secrecy (*e.g.* for national defense), original techniques, service-oriented concepts, or famous products that enjoy total confidentiality, such as Michelin tires or Coca-Cola.

Anteriorities that are not indexed and those that are kept under the seal of secrecy cannot be searched legally. In order to find them, one must invest in a search for novelty. This search is lengthy (several months); it can also be very expensive (between $50,000 and $100,000); it can also involve acts of unfair competition or industrial espionage (this can prove a hazardous business). In spite of the high costs and risks involved, one can never take for granted the result of such an investigation: there is always a possibility that, somewhere in the world, a third party will use a hitherto unknown anteriority to challenge the applicant's invention!

C) *Anteriorities related to copyright*:

—First category: Creative literary or artistic works that are registered at a recognized organization (copyright number ©, ISBN, SGDL, SACEM, etc.).

—Second category: Unregistered literary or artistic works that were created by an author and are therefore his property (because the author put them into concrete form onto a physical medium).

—Third category: Unpublished literary or artistic works that are registered under the © of copyright; in order to maintain secrecy, such works are not sent to a National Library; the USD-System method is based on such a strategy.

Whether they are published or unpublished,Works of the Mind are the property of their author. The latter enjoys for his entire lifetime plus fifty to seventy years after his death the exclusive right to produce, reproduce ©, and interpret his work. Among the most famous authors: Walt Disney, Hergé, even Pliny the Elder. [A literary text by Pliny the Elder (50 A.D.) was used to annul a twentieth century patent in a court of law (*Encyclopaedia Universalis*, Vol. 3, p. 597, 1971 edition).] Lesser known authors include the professors of the University of Colorado, who won a case in 1999 (see Exhibit B). They used copyright to successfully challenge a patent on their invention that a multinational from the same state had subsequently registered.

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One can probably find similar rulings on every continent.

Creating a Work of the Mind thereby establishing one's authorship of such a work is the unquestionable and universal proof of anteriority and property required to challenge third parties.

4. The Principles Underlying the Preponderant Anteriority of a Work of the Mind and the Evidence Required to Establish the Authorship of a Work

Given the excessive costs and huge risks inherent in patent application (or other titles), secrecy and copyright certainly seem far more affordable and attractive options for inventors, researchers, and small or medium-sized enterprises.

The benefits of secrecy are limited to the risk of disclosing one's concept or product; without proof of intellectual property (*i.e.*, a seizable personal property), there is no efficient legal recourse against such disclosure. The benefits of copyright are exclusively granted to creators of true literary and/or artistic works; in order to be indexed as Works of the Mind, such works must result from original creative acts. [Works of the Mind are indexed as works of art that result from a creative act. A work of art that does not result from a creative act is not a Work of the Mind since it does not require creative intuition. In other words, an individual who excels at making copies of works of art (for fraudulent purpose, for example) is an artist who does not create. Furthermore, in order to enjoy copyright and royalties, the author must also create his work according to the techniques and rules that govern a recognized art. Writing sentences or scrawling forms cannot establish authorship of a work of art, let alone of a Work of the Mind.]

There are racketeers who sell copyright registration to uninformed inventors; such copyright does not result from the creation of a literary or artistic work. These racketeers convince their victims that they enjoy "worldwide protection." Such illegal services are found on the Internet and sell for approximately $50 (a very low price compensated by a vast clientele). Various associations provide similar illegal services for a cost ranging from a few hundred to a few thousand dollars (*i.e.*, the life savings of an average inventor!). The inventor would reach the same result by mailing to his own address a registered letter in which he describes the invention or concept that he allegedly created (*i.e.*, his intellectual property). In reality, such a tactic can only prove that, on the date when the registered letter was mailed, the sender of the letter was aware of the invention or concept (much like the inventor who registers a presumed copyright). It does not prove that the sender is the true author of the invention or concept.

As we have noticed, merely proving that one is aware of an anteriority on a given date is not sufficient to claim copyright. In order to prove exclusive authorship of an original concept, one must describe it in a Work of the Mind. This proof of authorship has always been the only universal and legal means of establishing one's true ownership of a creation, hence of the resulting product or concept. This simply is the only form of unquestionable property! According to the internal laws of Nations and Article 17 of the Universal Declaration of Human Rights, no one can be arbitrarily denied such property.

Only a true literary or artistic Work of the Mind provides its author with an unquestionable and inalienable property and its resulting copyright. This is best illustrated by the following sequence: an original idea → Work of the Mind → inalienable property → copyright and royalties. The only payments required to strengthen the author's rights are optional: administrative fees for the registration of a Work of the Mind in order to provide formal and unquestionable proof of its existence at a certified date. Such fees do not exceed a few dozens of dollars.

A Work of the Mind provides its author with an inalienable, hence permanent and universal, property. Copyright grants exclusive rights that are expressly limited to the production, reproduction ©, and interpretation of the work. This means that in the industrial world, no one, without the author's consent, has the right to register a title of monopolistic commercialization (patent or other) or to commercialize the description of the original concept included in the author's work. Such acts constitute copyright infringement, including plagiarism of the author's property.

5. What Founds the Legal Value of Using the Intellectual Passport C.B. in Order to Own a Work

The "Intellectual Passport C.B." establishes authorship of a work (the owner) while maintaining secrecy by remaining unpublished. Thanks to the ownership of his work, the true author can, unlike the unidentified author who holds a secret, transact his commercial rights to third parties by signing contracts of license or assignment with or without non-disclosure covenants. If such contracts have non-disclosure covenants, unauthorized third parties cannot obtain the formula (recipe or process) without reproducing the original concept by illegal means, including criminal acts, unfair competition, industrial espionage, etc. Such criminal offenses inevitably leave a trail leading to the wrongdoer, who can then more easily be prosecuted.

Even in today's corporate world, when copyrighted material is involved, companies cannot freely distribute among their employees, subcontractors, sales representatives, or customers, documents such as instruction manuals or software without paying the due price to the author in accordance with the number of persons using it. Further proof of the strength of copyright and of printed documents in challenging the validity of patent follows.

Likewise, one cannot create a mould or make a given part without plagiarizing the designs that the author has included in the Intellectual Passport C.B. Similarly, how can one set up a technical or commercial system or disclose directions for use that are included in an Intellectual Passport C.B. without plagiarizing the author's texts? Moreover, if secrets are defined in an Intellectual Passport C.B., how could one acquire and thereafter copy them without the risk of being caught?

By using the Intellectual Passport C.B., the author (or group of authors) unquestionably becomes the *owner of the secrets*; in other words, he enjoys a "personal property" both tangible and seizable (see the Tri-Tex case), which can clearly be attributed to his efforts. Unlike the definitive ownership of a Work of the Mind, the holder of a title such as a patent holds a temporary commercial monopoly granted by sovereignty of State. Much like a license, this monopoly is granted under strict conditions: the holder must pay annual

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validation fees throughout the entire duration of the title. He must also promptly and efficiently extend and commercialize the title.

If, three years after delivery, the title holder still fails to fulfill his commercial obligations, a third party (whether or not he copied the invention) can obtain *ex officio* from a court of law a license to commercialize the title. One of patent's main limitations, this point surprisingly is eluded by experts on intellectual property. Such a procedure is in accordance with the law governing abuse of monopolistic titles (patent, design, or others). Ironically, such a law treats monopoly as a commercial matter that depends on the holder's financial means, and not as a legitimate right to commercialize one's original product. All of which proves that patent is a commercial title and not a property. This also explains why it is granted for a limited period of time. As we all know, temporary property is a misnomer: one had better call it a license or a lease.

In contrast with patent law, the author of a Work of the Mind enjoys an inalienable property. Consequently, he does not have to pay annual validation fees to maintain his authorship. Likewise, inaction on the author's part does not allow a third party to obtain *ex officio* a license to commercialize and/or produce the work. Such a property is granted without any obligation, since it results from the author's creative act. It depends neither on the grant of a monopoly nor on mandatory disclosure. In order to successfully challenge such a claim for property, a third party must file in court a Work of the Mind that is identical to the author's (including the same date). This is an unlikely event, to say the least!

Consequently, in order to copy, without his consent, all or part of the author's Work of the Mind for commercial purposes, one must commit a quadruple misdeed. The most obvious one is theft of the author's property. However, in order to perpetrate such an act, one has to violate private property. Indeed, there can neither be violation nor theft unless one appropriates an unquestionable property, which no one can arbitrarily be denied according to common law, the internal laws of most Nations, and the Universal Declaration of Human Rights. To these two misdeeds, one must add a third one, namely, that of imposture, since plagiarism implies deceitful intent to pass oneself off as the author and thus collect unwarranted gains. The fourth misdeed, namely unfair competition, is inherent in the perpetration of the first three misdeeds.

The Intellectual Passport C.B. is a product that allows each specialized enterprise participating in the various phases of the commercial development of a product to work in its own field of expertise. Such phases range from the origin (*i.e.,* creation) of the product or service to its ultimate use by society. This implies the following sequential order: creation → production → commerce. The Intellectual Passport C.B. was therefore conceived according to this sociological process which reflects the sequential order in which the complementary elements of commercial activity occur: creation (a new concept which never existed prior to being put into concrete form onto a physical medium); invention (a process, resulting from the concept, which already existed in the absolute, but had previously never been found); innovation (the final product or service, introduced into the market place,which resulted from the industrial and commercial development of the invention).

In conclusion, one can only praise the benefits of a commercial system based on the following sequential order: Creation (Intellectual Passport C.B.) → Invention (with or without a patent) → Innovation (through contracts of license or assignment). Once restored, this natural sequence allows the author to continue creating, the industrialist to continue producing, and the innovator to continue marketing, without any unnecessary interference and without internal conflict. Each one of them can therefore earn a living from his own trade. In such a system, nothing can prevent the inventor from taking his rightful place, namely that of author. This is logically and morally where he belongs.

6. Presenting the Intellectual Passport C.B.

The Intellectual Passport C.B., worldwide property that costs approximately the same as a mere national patent, is made up of three parts: 1) the historical account of the author, the description of the author's invention, and the legal means to defend his rights, 2) the business forecast for commercialization over a three year period, and 3) the sample contracts suited to the commercial strategy included in the forecast.

Part one describes and expresses in a historical account how the author (*i.e.,* the inventor) was inspired and thus imagined and conceived the virtual form of his creative idea. Legal, commercial, and philosophical texts are added to this account. True autobiography of the author, this historical account follows the chronological sequence of events, as well as the specific name and involvement of each individual who witnessed the author's adventure. This autobiography therefore represents a true certificate of universal anteriority for the inventor, who can thus concretely validate his prior personal possession and use it to challenge third parties in court. This section concludes with a technical and functional description of the invention.

Part two explains the commercial strategy chosen to launch the product. A synoptic chart plus several pages of marketing analysis provide the earnings before tax during a period of three years. Among other things, this business case allows one to assess the collective and individual interests of each party participating in the innovation's strategy (research, development, manufacturing, distribution, financing, sales, etc.) as well as the business volume, gross margins and royalties which, *a priori*, are difficult to calculate. A traditional business plan cannot include the numerous specialities that are involved in a commercial strategy. The inventor who purchases the Intellectual Passport C.B. is under no obligation to follow the business case when commercializing his product or concept. Nevertheless, this tool shows investors and financiers that the inventor has examined the business situation seriously. (See the chapter on distribution of rights, Paragraph C, pages 174 to 175, the book *Passport for Prosperity!*).

Part three includes personalized international sample contracts which support the commercial strategy that the inventor and his consultant chose in part two of the Intellectual Passport C.B. Much like the business case, when these sample contracts are delivered to the client, the latter is under no obligation to use them. However, they are specifically conceived to contractually assign or license the author's rights (*i.e.,* distribution of rights) to manufacturers, industrialists, producers of all kinds, distributors, financiers, or investors of all categories who are interested in commercializing the product.

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7. The Purpose of the Intellectual Passport C.B.

The *unpublished* Intellectual Passport C.B.was conceived in order:

1) To provide (within a short delay and at an affordable cost) a universal certificate of anteriority that establishes the inventor as the author of the invention or concept and provides him with the worldwide property that he needs.
2) To add (within a short delay and at an affordable cost) commercial and strategic value to the Intellectual Property of enterprises and independent inventors, as well as to authors of unpatentable ideas, services, concepts of all kinds, and others.
3) To evaluate (within a short delay and at an affordable cost) the business potential of the strategy that results from the commercialization of the invention or concept and the need for finding investors.
4) To organize (within a short delay and at an affordable cost) an effective commercial strategy that is suitable to the launching of the product or concept and to its subsequent technical development and commercialization; such a strategy takes into account the financial means required to commercialize the product or concept, while maintaining the author's secrecy as long as necessary prior to taking the market by surprise.
5) To establish (within a short delay and at an affordable cost) a new kind of contractual bonds based on joint liability that leads to an excellent relationship between the author of an invention or concept, the holders of commercial rights, and the investors. Such relationship provides greater security. Indeed, by co-signing a literary and artistic work, the directors of an enterprise/institute and its researchers/engineers can prevent former employees from committing acts of industrial and commercial espionage.

The *published* Intellectual Passport C.B. was conceived in order:
1) To create (within a short delay and at an affordable cost) a new kind of situation that allows the author whose original concept or invention was copied,to establish his rights and thus successfully claim compensation.
2) To prevent (within a short delay and at an affordable cost) illegal trade by copiers of all kinds worldwide.
3) To promote (within a short delay and at an affordable cost) the commercialization of the author's concept (and its resulting service) or invention (and its resulting product)—*i.e.,* "the innovation "—through the news and other media-related coverage such as literary programs, the launching of books, etc.

8. Concrete and Hypothetical Examples of How the Intellectual Passport C.B. Can Be Used Against Copiers in Order to Settle Conflicts

A. Concrete example: We shall conclude by demonstrating the effectiveness of this new product. The inventor of a computer program that has a worldwide commercial application became the author of a literary and artistic work (including the business forecasts and sample contracts). This work was produced by the USD-System editors as part of the series Intellectual Passport C.B. It is significant to note that the work: 1) was created in four original copies with the date of printing; 2) remained unpublished, thereby allowing the author to have his invention patented by a third party; 3) was registered at the Intellectual Property Office of the residence of the author with the date of registration and copyright number. Result: One month after his Intellectual Passport C.B. had been delivered, the author transferred his commercial rights to an industrialist for a large amount of money. Afterward,the industrialist hired a specialist who registered a patent and extended it internationally. Needless to say, given the potential market of his product, the author did not have the financial means of registering and maintaining an international patent.

B. Other examples of how the Intellectual Passport C.B. is used: Since this new product is also necessary—even essential—for unpatentable inventions, the market of Intellectual Property that it opens includes the conceptual designer of a new service as well as a craftsman's method, the creator of formulas of all kinds (*e.g.* for advertising), etc. Examples are legion. A shopkeeper who, unlike a franchiser, cannot afford to extend the rights to commercialize his original working and/or selling method, can, for a few thousand dollars, purchase access to the universal, permanent, and inalienable property provided by the Intellectual Passport C.B.

As one can easily understand from a legal point of view: the Intellectual Passport C.B. is a literary and artistic medium that expresses an original concept. In addition, as when performing an administrative act, the author of this work personally undertakes to include a description of his invention. As a medium, the validity of the Intellectual Passport C.B. cannot be challenged. However, given their professional code of ethics, the USD-System editors must provide the author with the appropriate guarantees and services (*e.g.* maintaining secrecy, joint liability with the author whenever their collective agreement is concerned, respecting law and order). Once the USD-System editors make this new product available to the legal profession, as well as to inventors, researchers, and conceptual designer of all kinds, it should become a very useful document for creators of enterprises (small, medium, and large-sized). Thus, as soon as they set up their business, the Intellectual Passport C.B. will guarantee the originality of their ideas. It will also prevent industrial and commercial espionage as well acts of unfair competition by former employees. This applies to scientific, commercial (franchise), technical or technological concepts, whether they concern the industry, services, or art.

C. For the settlement of conflicts: The lawyer who uses the Intellectual Passport C.B. knows that each of his clients has unquestionable rights related to a given competence. On the one hand, the inventor is free from the costs of international patent (or other monopolistic titles) and, on the other hand, the investor has the financial means to defend a monopolistic title internationally. By using the distribution of rights strategy (exposé Paragraph C, pages 174 and 175 of the book *Passport for Prosperity*!) the inventor will have the financial partners required to successfully defend his rights. Thus the Intellectual Passport C.B. provides greater security and efficiency, hence harmony.

Thanks to its strategy, which maintains secrecy and uses copyright (*i.e.,* maintaining the secrecy of an original idea in an unpublished seizable personal property), this original product allows greater access to Intellectual Property. Even though, as a rule, this literary work

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remains unpublished, the possibility of publishing it provides strategies that are not available under patent law. For example, the author might use its publication as part of an advertising campaign in order to prevent a third party from commercializing the concept or invention. Such a tactic is valid even in cases when the third party copied or stole the concept or invention prior to the creation of the Intellectual Passport C.B.

This is one of the retroactive virtues of this innovative product. At this point of the conference, one begins to realize the numerous benefits of editing literary works rather than registering industrial designs or patents.

Until the present, two inventors—a Frenchman and a Californian—have used this original strategy. After producing at a notary's office his unpublished Intellectual Passport C.B. (in which he included a description of his invention), the Frenchman obtained an out-of-court settlement that prevented a copier from commercializing his original product. As for the Californian, a copier had taken advantage of her hospitality in order to steal her service-oriented concept and launch it for himself on the market. Right from the outset, she stopped the copier's commercial activity by merely informing him that she would soon publish her Intellectual Passport C.B., thereby disclosing his wrongdoings. Thus, upon seeing a preliminary copy of the inventor's Intellectual Passport C.B., and without even reading its content, the copier almost immediately ceased his illegal activities. Thanks to this efficient strategy, the case was solved without any scandal; furthermore, it also led to a new Intellectual Passport C.B. written in English for a Berlin-based inventor.

Comment: In the first case, having seen the product on the market, the copier was not aware that the inventor had already included his concept in an unpublished Intellectual Passport C.B. Unable to find any anteriority in the Catalogue of Intellectual Property, he promptly registered his designs at an institute, in the hope of preceding the inventor. In the second case, the service-oriented concept could not satisfy the criteria of patent or of any other monopolistic title.

Fortunately for the inventor, this formula provides a prompt and inexpensive solution. Unfortunately for the unwavering supporters of jurisprudence, this formula eliminates lengthy and expensive procedures. Efficiency is the inventor's boon. Exposure is a plagiarist's nightmare.

Nota bene: When a patent is delivered prior to its date of publication, its validity can still be used to challenge third parties. Likewise, prior to its delivery, the anteriorities included in the patent application can also be used to challenge third parties. This proves that publication validates neither the commercial title nor the originality of the invention. Likewise, with regards to copyright, it is not the publication of a book that validates the author's ownership of his work.

There is a basic difference between titles of monopolistic commercialization and the ownership of a work: they serve opposite functions. Patent is mandatorily published, since its main function is to disclose new technologies in the Catalogue of Intellectual Property. As applied to the Intellectual Passport C.B., copyright first and foremost maintains the author's secrecy. Once his invention or concept is commercialized, it also allows the

Exhibit B. Synopsis of a decision rendered by the Court of Appeal of the U.S. Federal Circuit of Courts, in favor of the University of Colorado, on November 19, 1999 (#97-1468, 98-1113)

In the aforementioned case, the Court of Appeal of the United States' Federal Circuit of Courts examines several points concerning the illegal use of innovative ideas concerning a new formula for prenatal multivitamin food supplement, after professors at the University of Colorado had published such ideas as their discovery.

This ruling is very important in that it shows how the Intellectual Passport C.B. unquestionably is the best strategy when one wants to develop and market a patentable original idea. The invention allegedly had been discovered by several professors of the University of Colorado. Unbeknown to them, the multinational American Cyanamid Company (and Leon Ellensbogen), registered a patent claim on the original process of which they claimed authorship.

Alleging that the multinational had improperly taken advantage of their work, the professors asked the court to grant them compensation plus interests. Moreover, they also asked to be included among the patent holders for their invention.

The Court determined that the professors' recourse was well-founded by virtue of the laws of the State of Colorado. They were entitled to claim for the unauthorized (*i.e.*, illegal) use of their invention. Thus the judges of the Court of Appeal ordered the case to be heard by the Superior Court of first instance.

From a more technical point of view, the Court of Appeal also ruled that, having used, in its patent claim, part of an article written and published by the professors, the multinational had committed an illegal infraction by virtue of the Copyright Act. The Court of Appeal also ruled that, in certain cases, the author could obtain damages and interests. However, the Court determined that the professors did not prove their intention to commercially exploit their invention, thereby minimizing their claim for prejudice.

The Intellectual Passport allows the author of an invention to claim damages in cases of copyright infringement. Indeed, the figures included in the business forecast of the Intellectual Passport clearly prove that the inventor's intention to gain profits by marketing his intention. Furthermore, the Passport establishes the inventor's inalienable and universal property on his concept and/or product, and the Court can only grant full damages if such property and therefore its resulting rights are fully proven.

According to the Court of Appeal in the case presently considered, the professors can nevertheless claim a limited copyright infringement because the patent copies verbatim extracts from their article. The Court also allowed the professors to add their names to the list of patent holders of their invention.

The Intellectual Passport C.B. broadens considerably this recourse by allowing the inventors to enjoy full copyright resulting from unquestionable, universal, and inalienable intellectual property. Such recourse is therefore applicable on a worldwide basis, thus allowing the inventor to seek redress in any country where his invention is patented or simply copied illegally. Had the professors used the Intellectual Passport C.B., the first instance Court would have been able to render a simple and unequivocal ruling. It would have granted damages and interests proportionate to the prejudice suffered by the professors, without any need for a further hearing.

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author to earn royalties.

Should the Intellectual Passport C.B. lead to a trial, please refer to the case won by the professors of the University of Colorado (Exhibit B).

Afterword

Given the costs of international coverage, U.S. and other patents cannot meet the needs of inventors. Registration costs vary from $8,000 to $14,000 per country (agent fees and tax); protection in court requires $50,000 to $200,000 per country. Any anteriority can be used to annul patent registration. For $8,500, the Intellectual Passport C.B. provides inventors with unquestionable anteriority through a literary/artistic work: true universal property. It also includes a business forecast and a set of matching contracts.

About the Author

A graduate of the Estienne School of Arts and Crafts, Paris, France (C.A.P. chromatography, 1962), Mr. Dubois first devoted his talents to art, notably music and theatre. During the 1970s, he wrote songs while producing plays and variety shows. During the early 1980s, he decided to market one of his former inventions, an original printing method called "Cartisabelle." As a preemptive measure against fraudulent copy, Mr. Dubois created an exclusive sales network, the Art Service Club. In order to maintain secrecy, he chose not to patent his innovative method. By applying the "distribution of rights" principle, he extended his operations across most of Europe. This proved to be a turning point in his life, as he started envisioning a legal system that recognizes the paternity of inventors. Liberalizing access to intellectual property has been a long-standing concern for Mr. Dubois; he has written numerous booklets on the subject and has been interviewed on radio and television about the subject. In 1995, he introduced his ultimate product for inventors, the Intellectual Passport C.B. For distribution purposes, he founded what soon developed into an international consortium of editions: USD-System (Universal Strategy Development). This network regroups translators, writers, public relation experts, as well as specialists in marketing, sales, teaching, digital printing, etc. Already validated by lawyers in the U.S., Canada, and France, the Intellectual Passport C.B. is a dynamic instrument that promotes greater justice, better business relations, more creativity, hence more wealth for society. For those who wish to better understand the complexities of intellectual property, a book by Mr. Dubois entitled *Passport for Prosperity!* was recently published in French. Many booklets and the book are available at his website, www.univention.ca.

*5866 Park Avenue, Montreal, QC H2V 4H3 Canada
E-mail: mdubois@univention.ca

Parksie's Damn Dam

by Thomas Malloy

There once was a man named Parksie,
who taught physics in a universite.
Terriblie wedded was he to the existing physics orthodoxie,
most particularly General Relativite.

Parksie was offended,
by the experimenters who contended,
that revised,
the paradigm needed to be.

Boo hoo he sniffled,
if these results are accepted,
General Relativity will be rejected,
and then what will become of mie?

The worst of the offenders,
in this group of pretenders,
was an MD named Mills,
who should have prescribed pills.

But who instead spent his time,
working on a new paradigm,
which overturned the mechanics,
of quantum dynamics.

Now Doc Mills was a man with a very grand plan,
to extract energie,
from the electrons wizzing round
the hydrogen nuclie.

He accomplished this feat,
in a low pressure vessel,
with help of a metal,
from the group of metals known as the alkalie.

Now Parksie went ballistic,
when he read Mills' statistics.
If this is accepted, and his plan implemented,
then this country will have free energie!

Stop him I must, and stop him I shall,
said Parksie in a righteous huff.
I'll louse up his patent and we shall see,
if he can bring his device to the marketie!

But Doc Mills had some good attornie,
and they prevailed in the end,
and so it is obvious to all who can see,
that, try as you might, you can't stop human ingenuouitie!

Editor's Note: This poem was submitted by a loyal *Infinite Energy* subscriber. It may not be a serious contender for a poetry contest, but it does poke fun at the antics and attitudes of one Prof. Robert L. Park of the University of Maryland, who is also a spokesman for the American Physical Society (APS). Park—often disparaged on e-mail forums as "Parksie"—is notorious for his science paradigm paralysis and active efforts to obstruct the patent process for new energy inventions. The "MD named Mills" in the poem is Dr. Randell Mills of BlackLight Power Corp., who is a Harvard-trained physician, a new energy entrepreneur, and a serious critic of standard Quantum Mechanics. —*EFM*

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An Inside Look at a Catalyst Surface

Press Release—Lawrence Berkeley Lab (www.lbl.gov)

Editor's Introduction: This press release from a U.S. national laboratory highlights a very important recent article in *Nature* about chemical catalysis involving hydrogen on palladium surfaces. It may have very important implications for understanding what is happening in "cold fusion" or, as Dr. Les Case prefers to call it, "catalytic fusion." Indeed, there may be a spectrum of behaviors in surface catalysis ranging from those that regulate chemical reactions to those that provoke "unthinkable" nuclear reactions or the tapping of other kinds of vacuum energies. The new discovery about how many surface "active site" vacancies are required to adsorb or "hold" diatomic hydrogen suggests that at least three vacancies are required, not just two—contrary to what had been thought to be secure knowledge. Perhaps our basic understanding of the hydrogen atom is, indeed, wrong and needs revision? Perhaps chemical bonding theory is not on as secure ground as had been thought? It would be interesting for this work to be redone with heavy-hydrogen gas—an obvious extension of the present work that might shed further light on the cold fusion/LENR mystery. We agree with the Berkeley physicist who is quoted, "It reveals that we don't fully understand catalysis, even in simple systems." Science understands far less than he imagines. —*Eugene Mallove*

Three is better than two according to Berkeley Lab researchers who've debunked a longstanding assumption concerning how hydrogen molecules break apart and adhere to a catalyst surface.

Using scanning tunneling microscopy, the team determined that groups of three or more vacancies on a palladium surface are required to facilitate a process called dissociative hydrogen adsorption, in which a hydrogen molecule separates into two hydrogen atoms, each of which then occupy a vacancy.

Their research, reported in the April 17 issue of *Nature*, counters the widely held belief that only a pair of vacancies is needed to trigger hydrogen adsorption. The discovery may prompt scientists to rethink the underlying principles that drive many industrially important catalytic processes, such as those used in gasoline reformulation and hydrogen fuel cells.

"This paper is a call to theorists," says Miquel Salmeron, a physicist with Berkeley Lab's Materials Sciences Division. "It reveals that we don't fully understand catalysis, even in simple systems."

Catalyst surfaces supply chemical reactions with atoms. In a hydrogen fuel cell, for example, a metal surface adsorbs hydrogen atoms from a gas such as methane and supplies these atoms to an electrochemical reaction that generates electrical power. But although adsorption is a cornerstone of hundreds of catalytic processes, it is only partially understood. Researchers know that in order for a molecule to break apart and adsorb onto a catalyst surface, it must find a home among the surface's constantly fluctuating mix of atoms. If the molecule can't find this home, or active site, it bounces off.

Researchers also know that in many cases these active sites are composed of atom-free vacancies. Called atomic adsorption sites, these vacancies jitterbug across a catalyst surface, sometimes moving alone, sometimes forming short-lived clusters of two, three, or more. Every so often, this random dance brings together enough vacancies to create a home for a hydrogen molecule—a phenomenon at the heart of how catalyst surfaces work, and also where scientists' understanding becomes hazy. For years, they believed an active site needs only as many vacancies as the number of atoms in a molecule. To adsorb a hydrogen molecule's two atoms, only two vacancies must momentarily pair up. This assumption is repeated in many textbooks, and it makes sense—one vacancy for each atom—but it's wrong.

The truth didn't reveal itself until Salmeron and colleagues trained a scanning tunneling microscope onto a catalyst surface made of palladium. The microscope detects individual atoms, or the absence of atoms, using a probe that tapers down to a point only a single atom across. This atom-tipped probe skims across a surface, always maintaining the same current between it and the surface atoms. If the probe moves over an atom with an electron cloud that facilitates electronic conduction, it rises up. If it moves over an atom with an electron cloud that does not favor conduction, such as a hydrogen atom, the probe drops down. These irregularities are fed into a computer that produces an atom-by-atom contour map of the surface.

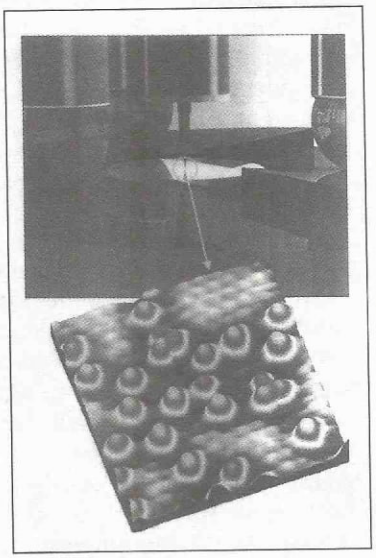

Figure 1. Under the scanning tunneling microscope, vacancies appear as red bumps in the image of a palladium surface. The two three-vacancy clusters, one located near the top and one on the right, can facilitate hydrogen adsorption.

Salmeron's team used this special microscope to observe the formation of sites that adsorb hydrogen. They cooled a palladium surface to an extremely low temperature, which slows its atomic movement, and exposed it to hydrogen molecules. They then watched what happened. Like a bird's eye view of people mish-mashing their way through a

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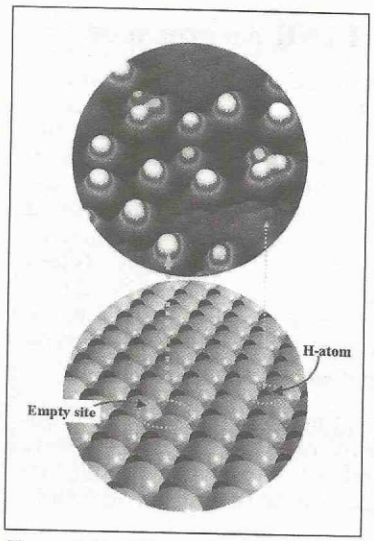

Figure 2. Hydrogen atoms don't favor conduction, so they appear much smaller than vacancies under a scanning tunneling microscope.

crowded train station, the vacant atomic adsorption sites skitter across the surface. When two vacancies bump together, creating the condition scientists long believed is ripe for hydrogen adsorption, nothing happens. The two vacancies merely dance together for a fraction of a second, then part ways.

"Although the pair of vacancies are constantly bombarded with hydrogen molecules, they never adsorb hydrogen atoms," Salmeron says. "This proves that two vacancies don't work."

But when three vacancies cluster together, two vacancies in the group quickly accept a hydrogen atom. This sequence of images, from a cluster of three vacancies to two adsorbed hydrogen atoms and one remaining vacancy, marks the first time the formation and function of an active site has been observed. The same holds true when the microscope captures four vacancies clustered together: hydrogen atoms soon fill two vacancies, leaving two remaining vacancies. Based on these images, the Berkeley Lab team concludes hydrogen adsorption requires active sites containing three or more vacancies. Why this is so, however, remains unanswered.

"We haven't solved a mystery. We've only unveiled a mystery," Salmeron says. "Two vacancies don't work, three or more are needed. Now it's up to the theoreticians to explain why."

Yet even as it poses questions, the team's research may enable scientists to more quickly refine catalyst systems. For example, a better understanding of the catalyst surface used in gasoline reformulation may lead to streamlined reformulation processes. In most cases, however, this pursuit of ever more efficient catalysts is guided by intuition and trial and error—a steady but slow process. Experimentally derived information, such as the three-or-more-vacancies rule, is a rare luxury that allows scientists to predict rather than guess how catalyst surfaces work, which could expedite their improvement.

"Our research helps take the guesswork out of making better catalysts," Salmeron says.

In addition to Salmeron, Toshi Mitsui, Mark Rose, Evgueni Fomin, and Frank Ogletree of the Materials Sciences Division contributed to the research.

Additional Information

"Dissociative Hydrogen Adsorption on Palladium Requires Aggregates of Three or More Vacancies," by T. Mitsui, M.K. Rose, E. Fomin, D.F. Ogletree, and M. Salmeron, *Nature*, April 17, 2003.

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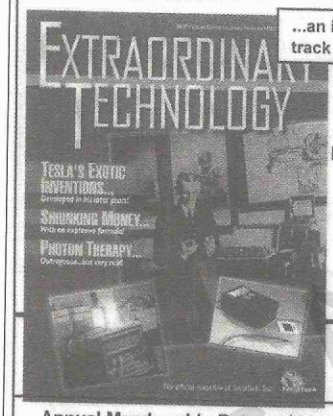

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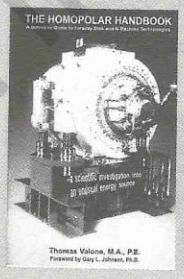

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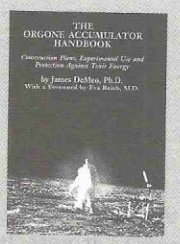

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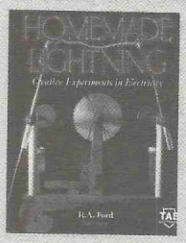

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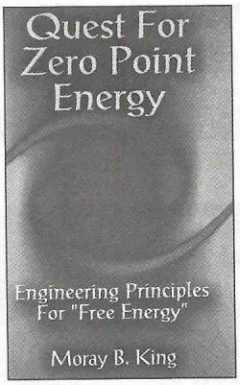

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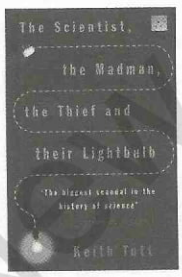

This is the U.S. release of the book originally titled *The Search for Free Energy*. Tutt presents the many new energy/free energy inventors of the past 100 years, from Nikola Tesla, to Stanley Pons and Martin Fleischmann, to Randell Mills and Alexandra and Paulo Correa; the book includes two chapters on the cold fusion field and its researchers.

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Short Course on LENR Announced

A short course on low-energy nuclear reactions (LENR) will be offered on Sunday, August 24, 2003, just preceding ICCF10. The course, organized by Dr. George Miley, will be held at the Royal Sonesta located in Cambridge, Massachusetts, site of ICCF10. Registration will be from 8:30 a.m. to 9:00 a.m. and the course will close at 5:30 p.m. The course registration fee of $130 ($60 for University/College students) will include: copies of notes, refreshments, and a light lunch. Space is limited, so advance registration is encouraged (contact Dr. Miley's office on e-mail at fsl@uiuc.edu or by phone at 217-244-4947). Lecturers will include: Drs. John Dash, Akito Takahashi, Peter Hagelstein, Mike McKubre, and Ed Storms.

Course Objective: This course is intended to provide an introduction to the field for persons interested in gaining a basic background in the science and technology aspects. Both theoretical and experimental topics will be covered for deuterium and proton based reactions.

9:00-9:15 a.m.	Introduction and Course Objectives (George Miley)
9:15-10:00 a.m.	Introduction to LENR (Ed Storms)
10:00-11:00 a.m.	Review of Experimental Measurements Involving DD Reactions (Mike McKubre)
11:00-11:30 a.m.	Coffee Break
11:30-12:30 p.m.	Review of Experimental Measurements Involving Transmutation Reactions (John Dash)
12:30-1:30 p.m.	Working Lunch, Discussion led by George Miley
1:30-2:30 p.m.	Theoretical Background for D Reactions (Peter Hagelstein)
2:30-3:30 p.m.	Theoretical Background for Transmutation Reactions (Akito Takahashi)
3:30-4:00 p.m.	Coffee Break
4:00-5:00 p.m.	Diagnostics for Measurements: Calorimetery, He^4, Transmutation Products and Isotopes, Radiation Emission, Metallurgical Analysis (George Miley, Mike McKubre, Ed Storms, and John Dash)
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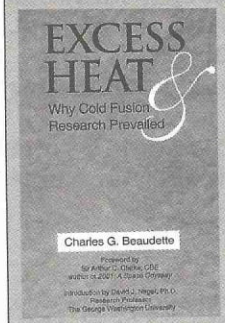

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Visit http://iccf10.org for detailed information.

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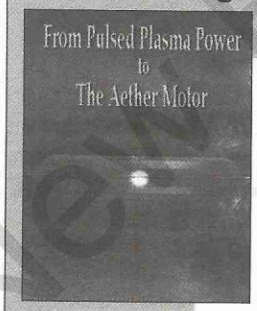

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Consistent with previous International Conferences on Cold Fusion, the goal of ICCF10 is to further scientific knowledge of effects—identified initially during 1989—with phenomena associated with anomalous, low-energy nuclear reactions in condensed matter. The conference is intended to be an open forum for scientific discussions related to the advancement of knowledge associated with this topic, including:

- Temperature increases, power and energy production in metal hydrides and deuterides; calorimetry relevant to such experiments.
- Correlations, or lack of correlations, between energy production and possible nuclear products.
- Materials science issues that are important for the development of nuclear effects in condensed matter.
- Electrochemical issues concerning loading, surface chemistry, resistance diagnostics and other issues concerning metal hydrides and metal deuterides that relate to anomalies.
- Observations of low-level dd-fusion reaction products in metal deuterides.
- Charged-particle, X-ray and gamma emission from metal hydrides and deuterides.
- Tritium production in metal hydride and metal deuterides.
- Production of new elements or isotopes in metal hydrides and metal deuterides; and modification of the associated isotopic distributions.
- Induced radioactivity in metal deuterides and metal hydrides.
- Accelerator experiments on metal deuterides and metal hydrides that pertain to screening and the anomalies.
- Screening between nuclei in the condensed matter environment.
- Models for relevant nuclear processes in the condensed matter environment.

Presentations/Demonstrations

Focused morning and early afternoon plenary sessions, as well as poster presentations in the later afternoon. There will be space for a limited number of exhibits, experiments, or working cold fusion devices. These will be presented in a laboratory at MIT, located within walking distance of the hotel. If you are interested in exhibiting, contact M.C.H. McKubre (michael.mckubre@sri.com).

Important Dates

One-page abstract submission	July 1, 2003
Pre-registration/hotel registration deadline	July 1, 2003
Notification of acceptance	July 30, 2003
Full paper submission	Sept. 10, 2003

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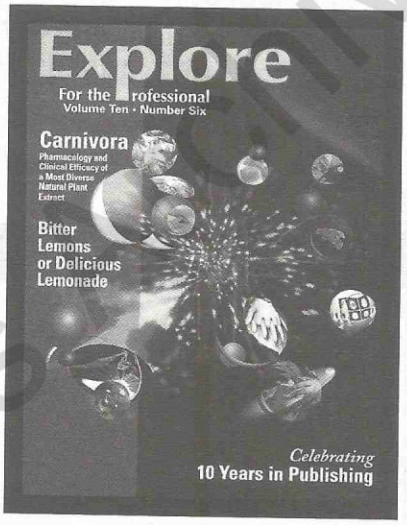

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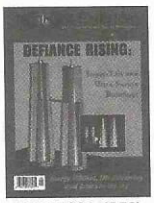

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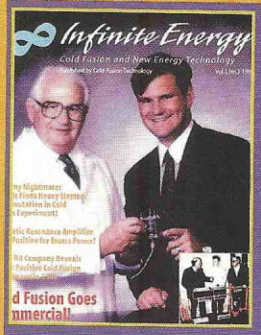

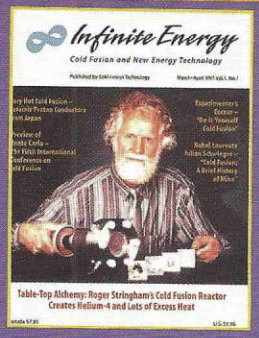

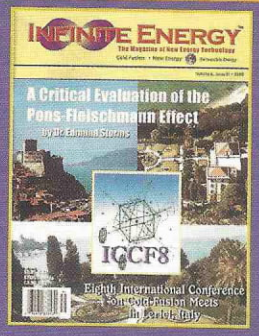

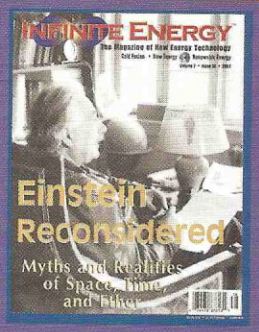

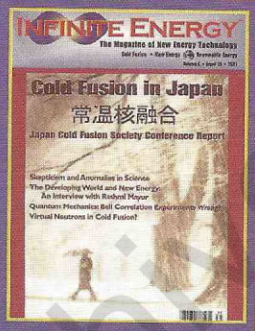

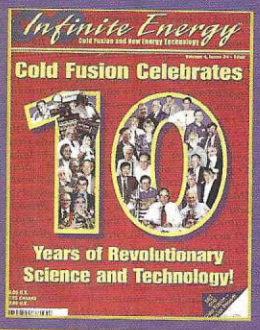

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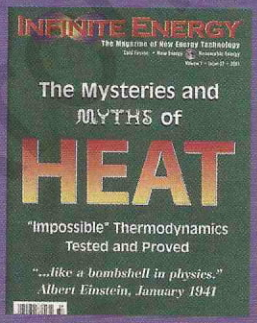

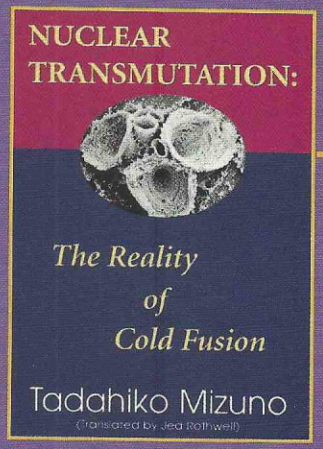

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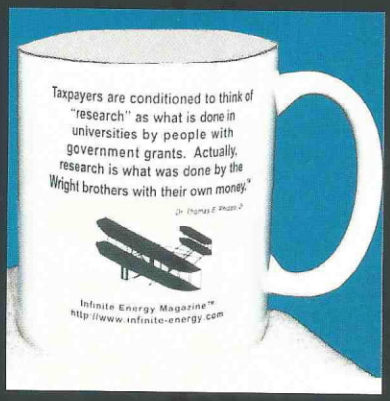

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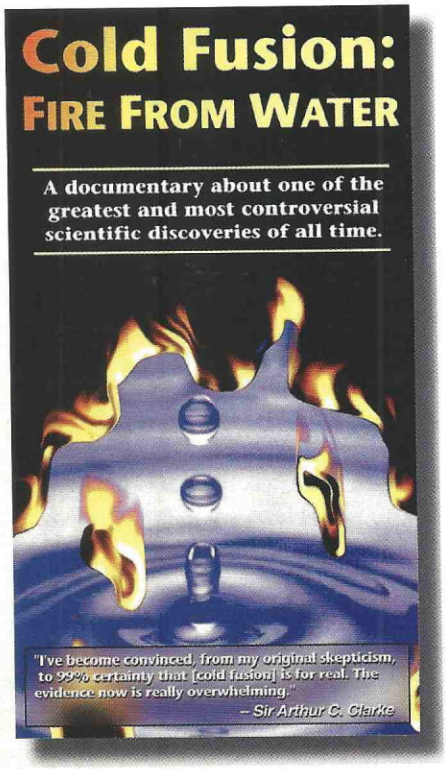

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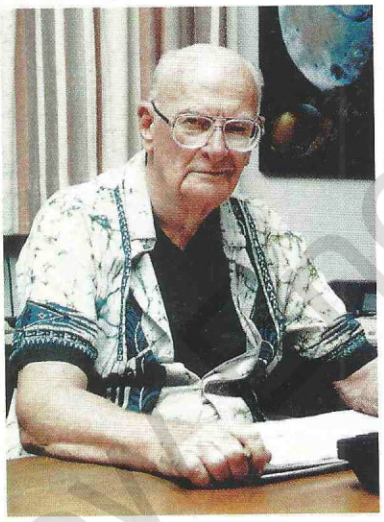

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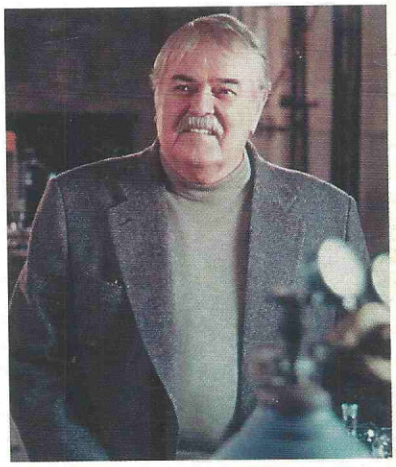

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